Sandia National Laboratories/New Mexico

PROPOSALS FOR NO FURTHER ACTION ENVIRONMENTAL RESTORATION PROJECT

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EXECUTIVE SUMMARY

Sandia National Laboratories/New Mexico is proposing a risk-based no further action (NFA) decision for Solid Waste Management Units (SWMU) 275, 10, 12B, 65E, 94A, 57A, 61A, 71, and 85. Review and analysis of all relevant data for these SWMUs indicate that concentrations of constituents of concern (COC) at these sites are less than applicable risk assessment action background levels. Thus, these SWMUs are proposed for an NFA decision based upon confirmatory sampling data demonstrating that COCs that may have been released from the SWMUs into the environment pose an acceptable level of risk under current and projected future land use, as set forth by Criterion 5, which states, "The SWMU/AOC [area of concern] has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998). Each of the above-listed SWMUs is briefly described below.

SWMU 275 (the Technical Area [TA] V Seepage Pits in Operable Unit [OU] 1306) contains two inactive septic tanks connected to six seepage pits. In 1994 preliminary investigations (including a subsurface active soil-gas survey that used direct-push borings and a surface passive soil-gas survey) were conducted at the site. Subsurface samples were taken from boreholes that had been drilled to the groundwater (520 feet) at the center of the seepage pit location. Based upon analysis results of these samples, the following residual COCs occur in isolated intervals within the borehole: metals, radionuclides, volatile organic compounds (VOC), and semivolatile organic compounds (SVOC). A separate ongoing groundwater investigation is being performed for the entire TA-V complex to address groundwater issues. The site assessment concludes that SWMU 275 does not have potential to affect human health under an industrial land use scenario. Because of the subsurface depth of the SWMU 275 seepage pits, no complete ecological pathways exist, and evaluation of ecological risk is not warranted.

SWMU 10 (the Burial Mounds in OU 1333) is an inactive site that contains primarily soil/debris from salvage operations that had been conducted after an accidental detonation of two mock weapons inside a bunker at the site. A radiological voluntary corrective measure (VCM) activities were performed in March 1995 and April—May 1996 to remove sources of radiological anomalies. A voluntary corrective action was taken in May 1998 to remove the vermiculite mound. The site assessment concludes that SWMU 10 does not have potential to affect human health under an industrial land-use scenario. After considering the uncertainties of related available data and modeling assumptions, it was determined that ecological risks associated with SWMU 10 were very low.

SWMU 12B (the Burial Site [Lurance Canyon] in OU 1333) is one of two subunits comprising SWMU 12. SWMU 12A (the Open Dump) had been previously submitted for an NFA decision in May 1997. SWMU 12B is located within the graded portion of SWMU 65D (the Lurance Canyon Explosive Test Site [LCETS]). The site is associated with debris generated during testing operations and historical grading activities in support of current Lurance Canyon Burn Site (LCBS) operations. In 1997 a VCM was performed at the site to excavate and characterize all fill material in the arroyo. The arroyo drainage was reestablished and stabilized. Analysis revealed the following residual COCs at SWMU 12B: metals, radionuclides, high explosives (HE), VOCs, and SVOCs. The site assessment concludes that SWMU 12B does not have significant potential to affect human health under a recreational land-use scenario. After

considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 12B were low.

SWMU 65E (the Far-Field Dispersion Area in OU 1333) is the farthest extent (far-field) fragmentation area associated with open-detonation tests at the LCETS. A radiological VCM was conducted at the site in March 1995, during May—June 1996, and in October 1996. Radiological VCM activities were conducted during March 1995 and May, June, and October 1996. Point sources and small area sources were removed in March 1995. Larger area sources were remediated in May, June, and October 1996. Sampling analysis revealed residual metals and radionuclides at the SWMU. The site assessment concludes that SWMU 65E does not have potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 65E were very low.

SWMU 94A (the LCBS Aboveground Tanks in OU 1333) is comprised of three aboveground storage tank locations: one active and two inactive areas where the tanks have been emptied and/or removed. The NFA addresses historical releases from all three aboveground storage tank locations. However, the active aboveground storage tank location is operating in compliance with all current applicable federal and state regulations and is not regulated under the Resource Conservation and Recovery Act. The aboveground storage tanks were used to store JP-4 and water in support of testing operations at the LCBS. Confirmatory sampling analysis at the site revealed the following COCs at the site: radionuclides, VOCs, and SVOCs. The site assessment concludes that SWMU 94A does not have significant potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 94A were very low.

SWMU 57A (the Workman Site: Firing Site in OU 1334) is a former artillery firing area that was active during World War II for the development of the proximity fuse—a radar-activated, variable-timed bomb fuse used in antiaircraft defense munitions. A variety of artillery pieces were used to fire test shells at targets suspended between the two former towers at SWMU 57B (the Workman Site: Target Area) located approximately 2 miles to the east. Confirmatory sampling analysis identified the following COCs at the site: metals, radionuclides, residual HE, SVOCs, VOCs, and polychlorinated biphenyl. The site assessment concludes that SWMU 57A does not have significant potential to affect human health under an industrial-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 57A were low.

SWMU 61A (the Schoolhouse Mesa Test Site: Blast Area in OU 1334) is an inactive explosives test site located within the former Area Z explosives testing area. SWMU 61A contains a previously cleared area, one long low debris mound located southwest of the cleared area, a second former debris mound located northwest of the cleared area, and three concrete blocks. Both mounds were dismantled during confirmatory sampling. A radiological VCM was performed in March 1995 and in February, March, May, July, and October 1996. Sampling analysis revealed the following residual COCs at the SWMU: metals, radionuclides, HE, VOCs, and SVOCs. The site assessment concludes that SWMU 61A does not have potential to affect human health under an industrial land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 61A were low.

SWMU 71 (the Moonlight Shot in OU 1334) is an explosives test site that was active from 1956 to 1961. Testing activities examined the possible radioactive fallout dispersion patterns that could result from a noncritical weapon detonation during transport or assembly scenarios. These airborne dispersion tests used depleted uranium in place of fissionable materials and yielded no nuclear fission products. A radiological VCM was performed during January—March 1995 and January—March 1996. Confirmatory sampling analysis revealed the following residual COCs at the SWMU: metals, radionuclides, and residual HE. The site assessment concludes that SWMU 71 does not have potential to affect human health under an industrial land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 71 were insignificant.

SWMU 85 (the Firing Site [Building 9920] in OU 1335) is an active test site where both aboveground and subsurface firing tests and reactor meltdown tests have been performed. A radiological VCM was performed in July and September 1995 and during March—June 1996. Sampling analysis revealed residual metals and HE COCs at the site. The site assessment concludes that SWMU 85 does not have significant potential to affect human health under an industrial land-use scenario. After consideration of the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 85 were insignificant.

REFERENCES

New Mexico Environment Department (NMED), March 1998. "RPMP Document Requirement Guide," Hazardous and Radioactive Materials Bureau, RCRA Permits Management Program, New Mexico Environment Department, Santa Fe, New Mexico.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Concluded)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Concluded)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

Table **Page**

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Concluded)

LIST OF ANNEXES

LIST OF ANNEXES (Continued)

LIST OF ANNEXES (Concluded)

Annex

ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
AOC	area of concern
AR/COC	analysis request/chain-of-custody
BCF	bioconcentration factor
bgs	below ground surface
BH	borehole
BLM	Bureau of Land Management
BTEX	benzene, toluene, ethylbenzene, and xylene
C	concrete sample
CA	Corrective Action
CCTA	Central Coyote Test Area
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeter(s)
cm^2	square centimeter(s)
COC	constituent of concern
COPEC	constituent of potential ecological concern
cps	count(s) per second
CTA	Coyote Test Area
CY	Canyon
D	debris sample
DCF	dose conversion factor
DOE	U.S. Department of Energy
dpm	disintegration(s) per minute
DQO	Data Quality Objective
DU	depleted uranium
EB	equipment blank
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERCL	Environmental Restoration Chemistry Laboratory
FCI	fuel coolant interaction
FITS	Fully Instrumented Test System
FOP	field operating procedure
ft	feet
g	gram(s)
GC	gas chromatography
GEL	General Engineering Laboratories
GPS	Global Positioning System
GR	grab sample
HASP	health and safety plan
HE	high explosive(s)
HEAST	Health Effects Assessment Summary Tables

ACRONYMS AND ABBREVIATIONS (Continued)

HI	hazard index
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane
HP	Health Physics
HRMB	Hazardous and Radioactive Materials Bureau
HRS	Hazard Ranking System
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
ID	identification
I.D.	inner diameter
IH	Industrial Hygiene
IRIS	Integrated Risk Information System
KAFB	Kirtland Air Force Base
kg	kilogram(s)
L	liter(s)
LAARC	Light Airtransport Accident Resistant Container
LAS	Lockheed Analytical Services
lb	pound(s)
LCETS	Lurance Canyon Explosives Test Site
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LOAEL	lowest-observed-adverse-effect level
Log	logarithm (base 10)
LWDS	Liquid Waste Disposal System
m^3	cubic meter(s)
MDA	minimum detectable activity
MDC	melt development corium
MDL	method detection limit
mg	milligram(s)
mi	mile(s)
mL	milliliter(s)
mrem	millirem(s)
MS	mass spectrometry; matrix spike
MSD	matrix spike duplicate
µg	microgram(s)
µR/hr	microroentgen(s) per hour
NC	not calculated
ND	not detected
NFA	no further action
NG	nitroglycerin
NLM	National Library of Medicine
NMED	New Mexico Environment Department
NOAEL	no-observed-adverse-effect level
NRC	U.S. Nuclear Regulatory Commission
NT	not tested

ACRONYMS AND ABBREVIATIONS (Continued)

O.D.	outside diameter
OB	Oversight Bureau
OP	operating procedure
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi	picocurie(s)
PID	photoionization detector
ppbv	part(s) per billion by volume
PPE	personal protective equipment
ppm	part(s) per million
PQL	practical quantitation limit
PRG	preliminary remediation goals
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RCT	radiation control technician
RDX	1,3,5-trinitro-1,3,5-triazacyclohexane
RFA	RCRA facility assessment
RFI	RCRA facility investigation
RME	reasonable maximum exposure
RMMA	Radioactive Materials Management Area
RP	Radiation Protection
RPD	relative percent difference
RPSD	Radiation Protection Sample Diagnostics
RSI	Request for Supplemental Information
S	soil sample
SAP	sampling and analysis plan
SD	soil sample duplicate
SFN	silt fence (north)
SFSW	silt fence (southwest)
SNL/NM	Sandia National Laboratories/New Mexico
SOV	soil organic vapor
SSO	soil sample
SVOC	semivolatile organic compound
SVS	soil vapor survey
SWHCP	Site-Wide Hydrogeologic Characterization Project
SWMU	solid waste management unit
SWTA	Southwest Test Area
TA	Technical Area
TABS	Torch-Activated Burn System
TAL	target analyte list

ACRONYMS AND ABBREVIATIONS (Concluded)

TCE	trichloroethylene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TEDE	total effective dose equivalent
Tetryl	2,4,6-trinitrophenylmethylnitramine
TIC	total ion counts
TPH	total petroleum hydrocarbon
US	soil sample
USAF	U.S. Air Force
USFS	U.S. Forest Service
UTL	upper tolerance limit
UXO	unexploded ordnance
XRF	x-ray fluorescence
VCM	voluntary corrective measure
VOC	volatile organic compound
WACC	Water Quality Control Commission
yr	year

1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing No Further Action (NFA) Proposals for nine Environmental Restoration (ER) Solid Waste Management Units (SWMUs). The following SWMUs are listed in the Hazardous and Solid Waste Amendments Module IV (EPA August 1993) of the SNL/NM Resource Conservation and Recovery Act Hazardous Waste Management Facility Permit (NM5890110518) (EPA August 1992). Proposals for each SWMU are located in this document as follows:

Operable Unit 1306

- SWMU 275, TA-V Seepage Pits (Section 2.0)

Operable Unit 1333

- SWMU 10, Burial Mounds (Section 3.0)
- SWMU 12B, Burial Site (Section 4.0)
- SWMU 65E, Far-Field Dispersion Area, Lurance Canyon Explosive Test Site (Section 5.0)
- SWMU 94A, Aboveground Tanks, Lurance Canyon Burn Site (Section 6.0)

Operable Unit 1334

- SWMU 57A, Workman Test Site: Firing Site (Section 7.0)
- SWMU 61A, Schoolhouse Mesa Test Site: Blast Site (Section 8.0)
- SWMU 71, Moonlight Shot Area (Section 9.0)

Operable Unit 1335

- SWMU 85, Firing Site (Building 9920) (Section 10.0)

These proposals each provide a site description, history, summary of investigatory activities, and the rationale for the NFA decision.

3.0 SOLID WASTE MANAGEMENT UNIT 10, BURIAL MOUNDS

3.1 Summary

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based no further action (NFA) decision for Solid Waste Management Unit (SWMU) 10, Burial Mounds, Operable Unit (OU) 1333. SWMU 10 is an inactive site comprised primarily of soil/debris from construction of bunkers at SWMU 60, from grading operations performed to maintain access to the site, and from salvage operations conducted after explosives testing activities. Primary sources of constituents of concern (COC) for SWMU 10 were depleted uranium (DU), high explosives (HE), and metals associated with accidental detonation of two mock weapons. Other tests conducted at the site may have contributed to contamination at SWMU 10 also, but specific details regarding those tests are unknown. Analytical results indicated that no residual HE compounds are present in the soil/debris mounds or surrounding surface soils (see Section 3.4.4.3). A radiological voluntary corrective measure (VCM) was conducted in 1996 to remove radiological anomalies associated with the soil/debris mounds. A voluntary corrective action (VCA) was conducted in 1998 to remove the vermiculite mound.

Review and analysis of all relevant data indicate that concentrations of COCs at this SWMU are less than applicable risk assessment action levels. Thus, SWMU 10 is being proposed for an NFA decision based upon confirmatory sampling data demonstrating that COCs that may have been released from this SWMU into the environment pose an acceptable level of risk under current and projected future land use, as set forth by Criterion 5 which states, "The SWMU/AOC [area of concern] has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998).

3.2 Description and Operational History

Section 3.2 describes SWMU 10 and discusses its operational history.

3.2.1 Site Description

SWMU 10 (Figure 3.2.1-1) is associated with SWMU 60 and is located near the northeastern corner of Kirtland Air Force Base (KAFB), on federally owned land controlled by KAFB (SNL/NM July 1994a). Access to the general area is by Coyote Springs Road to Pendulum Road and then approximately 1.5 miles north (Gaither Date [Unk]; Oldewage May 1993). The site lies on approximately 2.9 acres at a mean elevation of 6,175 feet above sea level (SNL/NM April 1995).

SWMU 10, Burial Mounds, inactive since the late 1970s, consists of nine soil/debris mounds, one former soil/debris mound removed in April 1996, and a former vermiculite mound removed in May 1998. The former soil/debris mound was removed in conjunction with a radiological

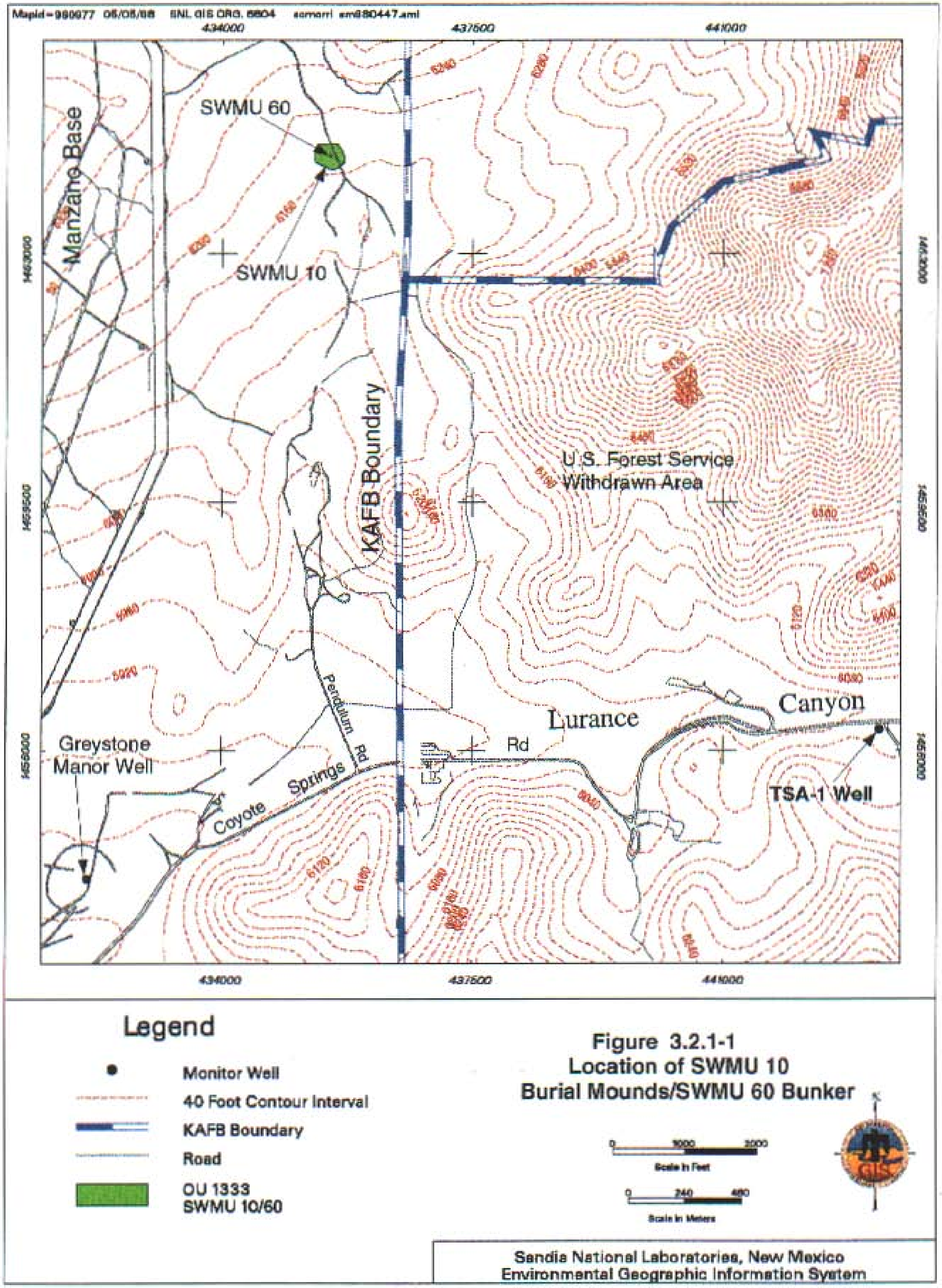

Figure 3.2.1-1
Location of SWMU 10
Burial Mounds/SWMU 60 Bunker

VCM (Section 3.4.4). The former vermiculite mound was removed as solid waste in a VCA (Section 3.4.5). The site boundary was established based upon the fragmentation radius of DU fragments found in the initial surface gamma radiation survey conducted in October 1993 (RUST Geotech Inc. December 1994).

SWMU 10 lies on Tesajo-Millett stony sandy loams that are underlain by igneous and metamorphic Precambrian rocks (USDA June 1977). Immediate topographic relief around the site is approximately 50 feet (Figure 3.2.1-1). The nearest monitoring wells, the Graystone Manor and TSA-1 Wells, are located approximately 2.2 miles southwest and southeast of SWMU 10, respectively (Figure 3.2.1-1). Groundwater conditions at TSA-1 are probably more representative of conditions at SWMU 10, because SWMU 10 and TSA-1 are east of the Coyote Fault on thin alluvium deposits surrounded by Precambrian rocks (IT May 1994). At TSA-1 well, semiconfined to confined groundwater is encountered in fractured Precambrian bedrock at a depth of 180 feet below ground surface (bgs) (IT May 1994). Local groundwater flow in the vicinity of SWMU 10 may be complicated because of abundant fractures and faults in the area.

For a detailed discussion of the local setting and other information pertaining to SWMU 10, refer to the "RCRA [Resource Conservation and Recovery Act] Facility Investigation Work Plan for Operable Unit 1333, Canyons Test Area" (SNL/NM September 1995).

3.2.2 Operational History

The nine existing soil/debris mounds and one former soil/debris mound comprising SWMU 10 are designated 1 through 10 to simplify discussion in this NFA proposal, and these numbers have no historical basis. The former vermiculite mound, not given a numerical designation, was located directly south of Mound 4 (Wrightson September 1993). Some of the mounds have been removed or modified in conjunction with a radiological VCM and solid waste VCA. Mounds 1 through 7 and Mound 10 are located west of Pendulum Road and the SWMU 60 bunkers (Figure 3.2.2-1). Mounds 8 and 9 are located east of Pendulum Road (Figure 3.2.2-1). Table 3.2.2-1 provides a summary of the mounds and their original area/extent, modifications to the mounds during remediation, and the mounds final configuration.

When most of the mounds were constructed is unknown and cannot be determined through the available historical aerial photographs (SNL/NM August 1994). However, the majority of soil mounds were reportedly in place before January 4, 1979, when the Torch-Activated Burn System (TABS) experiment was conducted at the SWMU 60 control bunker (Kurowski January 1979, Larson August 1994, Larson and Palmieri August 1994a, Larson and Palmieri August 1994b). Interview records confirm that the non-TABS-related soil mounds (i.e., Mounds 1, 2, 4, 7, 8, 9, 10, and part of 6) were probably generated when the SWMU 60 bunkers were constructed and possibly during grading operations in the arroyo channel, which had been used as access to the site (Larson and Palmieri September 1994, Larson August 1994). Mounds 3 and 5 and the south end of Mound 6 consist of sifted material derived from salvage operations that had been conducted after the TABS test. It is believed that the former vermiculite mound west of the bunkers originated from radioactive tracer experiments (osmium-191) that had been conducted in a vermiculite pit prior to the 1979 TABS test (Wrightson September 1993). Interviews confirm that at the conclusion of the tests in the pit the vermiculite was screened by

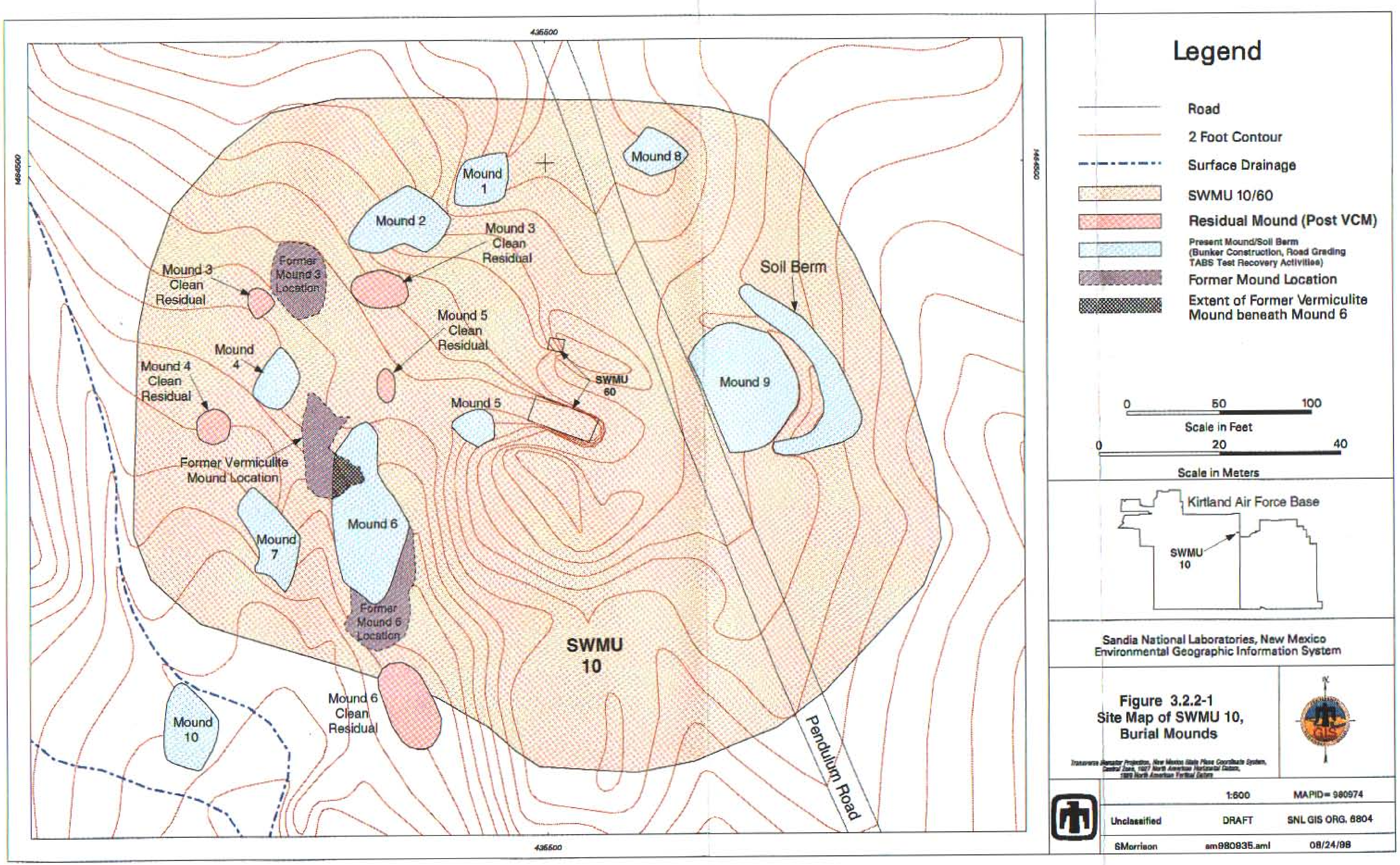

Figure 3.2.2-1
Site Map of SWMU 10,
Burial Mounds

Table 3.2.2-1
Summary of Remedial Actions Conducted
On SWMU 10 Soil/Debris Mounds

SWMU 10 Mounds	Original Areal Extent (ft^2)	Remedial Actions Conducted	Present Mound Configurations	Present Areal Extent (ft^2)
Mound 1	680	None	No Change	680
Mound 2	1,298	None	No Change	1,298
Mound 3	979	Radiological VCM Conducted, Mound 3 Completely Dismantled and Radiological Anomalies Removed	Mound 3 Completely Removed, Two Post-VCM Clean Soil Residual Mounds Remain	497 (east) 164 (west)
Mound 4	539	Radiological VCM Conducted, Mound 4 Partially Dismantled and Discrete Radiological Anomalies Removed	Mound 4 and One Post-VCM Clean Soil Residual Mound Remain	274
Mound 5	325	Radiological VCM Conducted, Mound 5 Partially Dismantled and Discrete Radiological Anomalies Removed	Mound 5 and One Post-VCM Clean Soil Residual Mound Remain	142
Mound 6	2,446	Radiological VCM Conducted, Mound 6 Partially Dismantled and Radiological Anomalies Removed Throughout	Southern Portion of Mound 6 Removed. Northern Portion of Mound 6 and One Post-VCM Clean Soil Residual Mound Remain	1,109 (former Mound 6) 1,067 (clean residual)
Mound 7	1,007	None	No Change	1,007
Mound 8	568	None	No Change	568
Mound 9	2,836	None	No Change	2,836
Mound 10	1,013	None	No Change	1,013
Vermiculite Mound	1,070	Solid Waste VCA Conducted, Vermiculite Mound Completely Removed	No Pre- or Post-VCA Residuals from the Vermiculite Mound Remain	0

ft^2 = Square feet.
SWMU = Solid waste management unit.
VCA = Voluntary Corrective Action.
VCM = Voluntary Corrective Measure.

the shovelful and that no elevated radioactivity was detected (Wrightson September 1993). Part of the former vermiculite mound may have originated when bags of vermiculite were removed from storage in the supply bunker at SWMU 60 (Palmieri November 1994). SWMU 10 has been inactive since the late 1970s (EPA April 1987). Figure 3.2.2-2 presents the actual locations of the ten current and former soil/debris mounds and the former vermiculite mound.

The TABS test was conducted in the SWMU 60 control bunker to investigate the feasibility that remotely burning HE contained in nuclear weapons would not induce an explosion (Kurowski January 1979). However, two mock weapons containing HE, DU, and beryllium detonated (Kurowski January 1979), destroying the control bunker and scattering debris around SWMU 10. Mounds 3 and 5 and the south end of Mound 6 were produced from salvage operations that attempted to recover test materials, DU, and undetonated HE (Larson August 1994, Larson and Palmieri August 1994a). During a survey conducted by SNL/NM Industrial Hygiene and Radiation Protection Operation (RPO) personnel after the TABS test, DU fragments were removed and buried at the mixed waste landfill in Technical Area III (Larson August 1994).

Scrap metal and wood debris are associated with some of the non-TABS soil mounds. However, specific test activities that produced the debris are unknown. One interview record states that containment-type tests were conducted with short half-life radionuclides in the bunker (SWMU 60) north of the Pendulum Site (SWMU 59), and the mounds contain the remnants of these tests (Martz October 1985). Similarly, another interview record states that a test involving a radioactive osmium-191 tracer was conducted in the bunker (SWMU 60) near the Pendulum Site (SWMU 59) (Author [Unk] Date [Unk]a). A test engineer involved in the radioactive tracer experiments stated that osmium tetra oxide was the tracer compound used and that the test involved a vermiculite catch pit located about 100 feet southwest of the bunker (Wrightson September 1993). This implies that the tests were performed in the area of the vermiculite mound rather than in the bunkers (Figure 3.2.2-1). The test engineer also stated that the osmium-191 tracer had a half-life of about 16 days (half-life for osmium-191 is 15.4 days [GE 1989]). Details regarding the test setup and number of tests were not available.

3.3 Land Use

Section 3.3 discusses the current and future proposed land uses for SWMU 10.

3.3.1 Current

SWMU 10 is located within the boundaries of KAFB and is currently an inactive site (Figure 3.3.1-1).

3.3.2 Future/Proposed

SWMU 10 has been recommended for industrial land use in the future (DOE and USAF March 1996). However, the risk associated with SWMU 10 has also been assessed for residential land use because the site is in proximity to private housing developments (see Section 3.5.2.1).

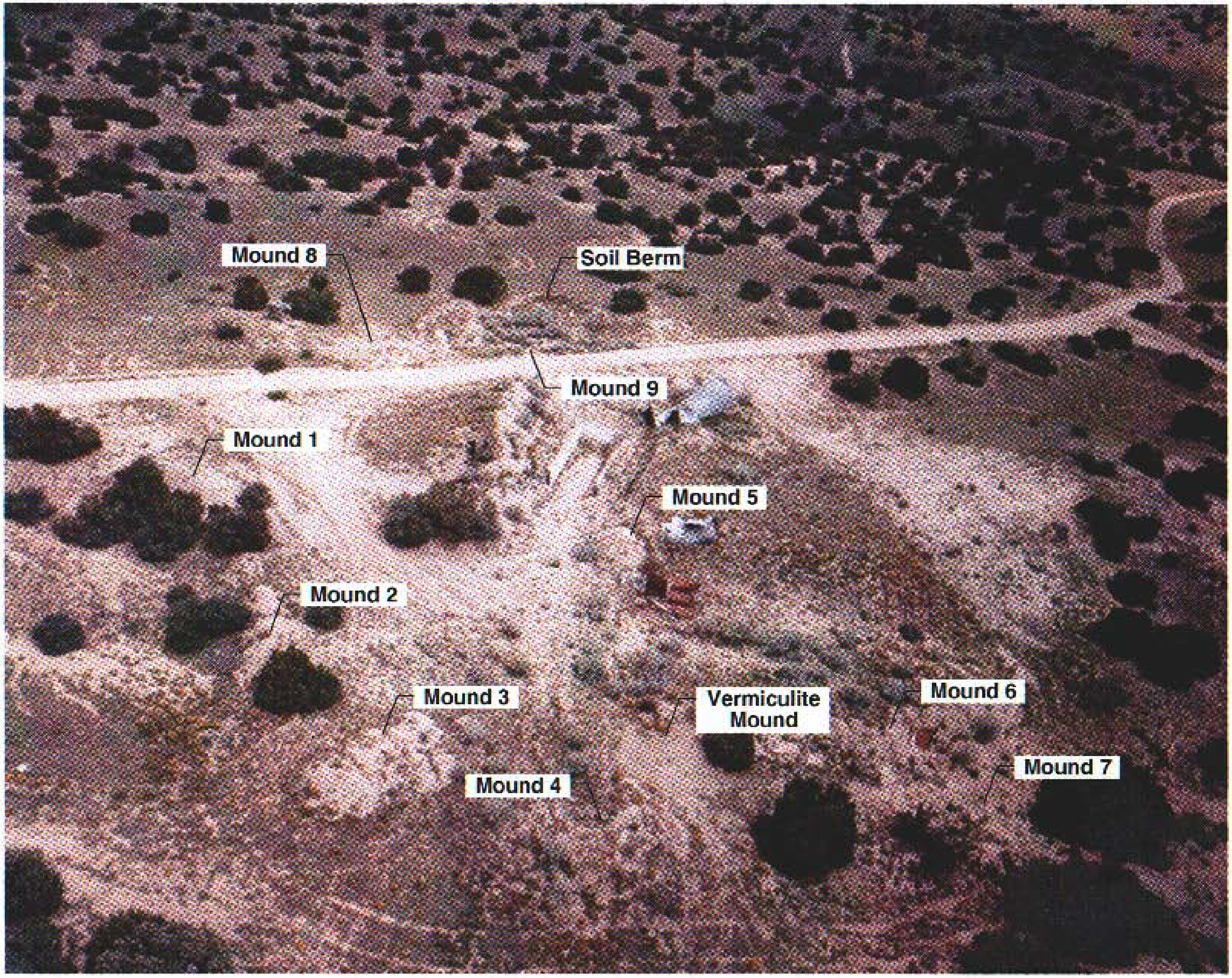

Figure 3.2.2-2 Actual locations of SWMU 10 burial mounds (Mound 10 not shown, located to the right of Mound 7).

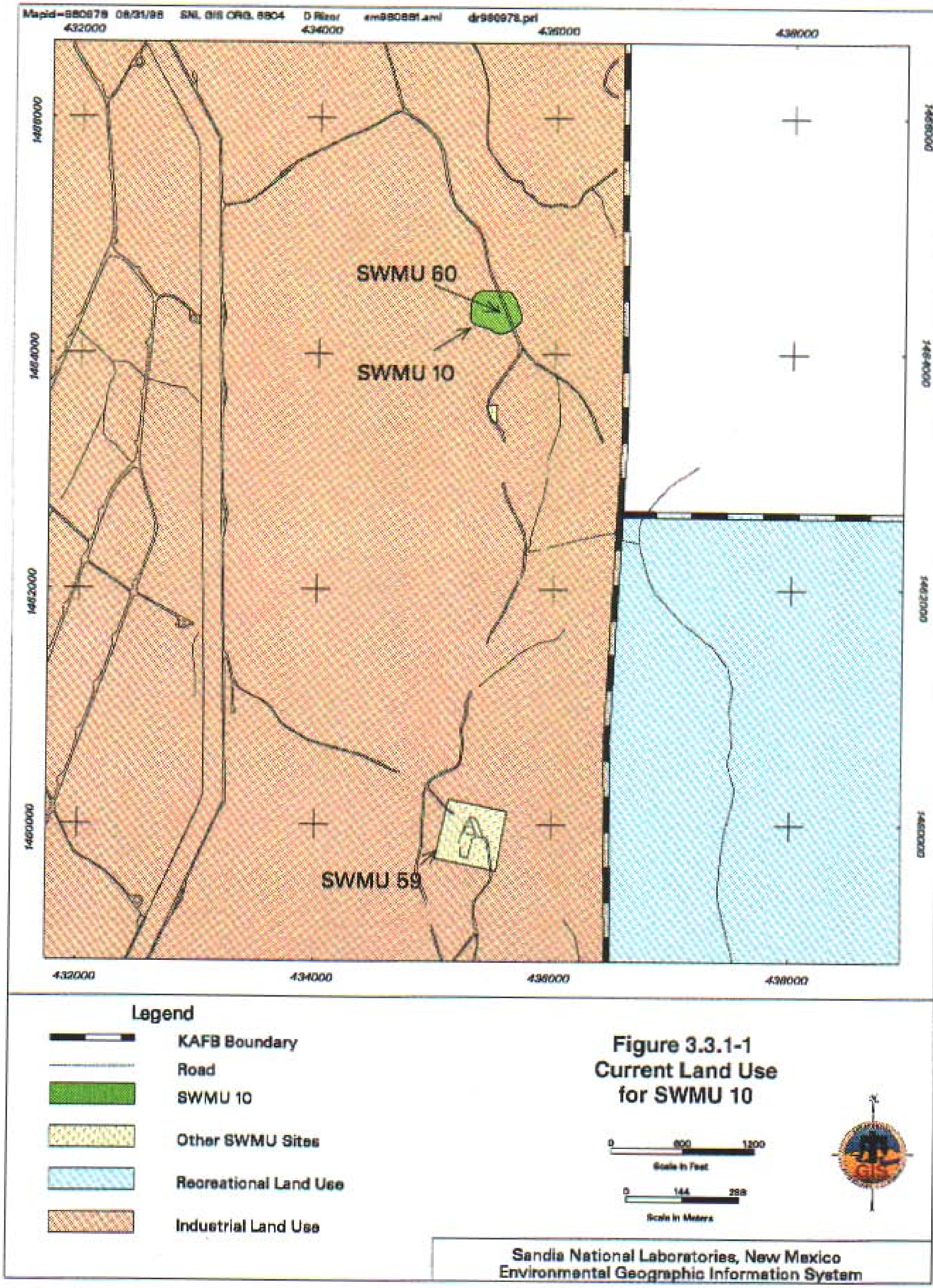

Figure 3.3.1-1
Current Land Use for SWMU 10

3.4 Investigatory Activities

SWMU 10 has been characterized and/or remediated in a series of four investigations and VCM/VCA activities. Section 3.4 discusses these activities.

3.4.1 Summary

SWMU 10 was investigated initially under the U.S. Department of Energy (DOE) Comprehensive Environmental Assessment and Response Program (CEARP) in the mid-1980s in conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The investigation included collecting nonsampling data and inspecting the site (Investigation #1). In 1989, preliminary investigations began that included unexploded ordnance (UXO)/HE, radiological, cultural-resources, and sensitive-species surveys and scoping sampling (Investigation #2). A radiological VCM was conducted, followed by confirmatory sampling (Investigation #3). A solid waste VCA was performed at the site to remove a vermiculite mound and was followed by confirmatory sampling (Investigation #4).

3.4.2 Investigation #1—Comprehensive Environmental Assessment and Response Program

3.4.2.1 Nonsampling Data Collection

SWMU 10 was first listed as a potential release site based upon the CEARP interviews in 1985. The CEARP Phase I draft report (DOE September 1987) stated that several burial mounds are located in the bunker area (SWMU 60) north of the Pendulum Site (SWMU 59). During the preliminary site investigation, it was observed that scrap metal and small pieces of shrapnel protruded from some of the mounds, that HE were on the surface, and that the mounds contained debris (such as DU, radioactive tracers [osmium-191], beryllium, lead, and/or HE) derived from various explosives testing activities (DOE September 1987).

3.4.2.2 Sampling Data Collection

No samples were collected at SWMU 10 during the CEARP.

3.4.2.3 Data Gaps

No confirmation samples were obtained during the CEARP to confirm whether hazardous materials or wastes were stored or released to the surrounding environment.

3.4.2.4 Results and Conclusions

The CERCLA finding under the CEARP was positive for Federal Facility Site Discovery and identification findings, preliminary assessment, and preliminary site investigation, but insufficient information was available to calculate a Hazard Ranking System score for the SWMU.

3.4.3 Investigation #2—SNL/ER Preliminary Investigations

3.4.3.1 Nonsampling Data Collection

This section describes the nonsampling investigation data collected at SWMU 10.

3.4.3.1.1 Background Review

A background review was conducted in order to collect available and relevant information regarding SWMU 10. Sources included interviews with SNL/NM staff and contractors familiar with the site's operational history and reviews of existing site records and reports. The study was documented completely and has provided traceable references that sustain the integrity of the NFA proposal. The following sources were used to assist in evaluating SWMU 10.

- Two SNL/NM technical reports on past site TABS testing activities (Kurowski January 1979, SNL/NM February 1979)
- Six historical aerial photographs spanning the years 1951 to 1992 (SNL/NM August 1994)
- Eight interviews with seven current and retired facility personnel (Martz October 1985, Larson and Palmieri September 1994, Larson August 1994, Brouillard June 1994, Larson and Palmieri August 1994a, Larson and Palmieri August 1994b, Palmieri November 1994, Wrightson September 1993)
- Photographs and field notes from numerous site inspections conducted by SNL/NM Environmental Restoration (ER) staff (Author [Unk] Date [Unk]b, Gaither January 1994, Gaither Date [Unk], Gaither November 1992, Author [Unk] Date [Unk]a, Author [Unk] Date [Unk]c, Gaither May 1992, Burton February 1987).

3.4.3.1.2 UXO/HE Survey

In September 1993, KAFB Explosive Ordnance Disposal personnel conducted a visual surface survey for UXO/HE on the ground surface of SWMUs 10 and 60. One live ground burst simulator was found and was removed in June 1994. The ordnance debris that were removed included twelve expended smoke grenades, two practice 40-millimeter grenades, three expended smoke pots, five empty White Star parachute containers, one empty homemade booby trap, one empty Molatov Cocktail, various pieces of unidentified rockets, and expended blank 7.6-mm and 5.6-mm ammunition (Young September 1994). It is believed that these materials are associated with KAFB war game operations.

3.4.3.1.3 *Radiological Survey(s)*

In addition to the DU removal activity after the TABS test in 1979, a 1989 radiation survey of SWMUs 10 and 60 conducted by SNL/NM RPO identified an area of radioactively-contaminated vermiculite. The radioactively-contaminated vermiculite was removed in 1989 and disposed of as radioactive waste. The remaining vermiculite mound was free of radioactive contamination (Gaither January 1994, Minnema and Tucker August 1989, Larson August 1994).

In May 1993, SNL/NM RPO conducted a radiation survey of the road leading to SWMU 10. Adhesive swipes that had been placed on the underside of the vehicle were analyzed and revealed no contamination, nor was airborne radioactivity detected in the dust kicked up by the vehicle (Oldewage May 1993).

In October 1993, RUST Geotech Inc. conducted a Phase I surface gamma radiation survey of SWMUs 10 and 60. The survey was conducted on 6-foot centers and covered 100 percent of the site. The areas of gamma activity greater than 30 percent above natural background (10 to 16 microroentgens per hour [µR/hr]) included the following (Figure 3.4.3-1) (SNL/NM September 1997):

- 31 point source and small area source anomalies
- 21 randomly-located soil area source anomalies

In February 1994, SNL/NM RPO personnel conducted a follow-up beta-gamma radiation survey at SWMUs 10 and 60 (SNL/NM September 1995). None of the measured swipe-sampled anomalies yielded removable contamination above the action levels detailed in DOE Order 5400.1, "General Environmental Protection Program," nor were radiation levels greater than 5 µR/hr at a distance of 1 foot. It is suspected that RUST Geotech anomalies 60E36, 60E39, 60E41, 60E42, 60E43, 60E44, and 60E45, identified in the Phase I survey, resulted from bedrock outcrops of granitic composition (Oldewage February 1994).

The anomalies were analyzed using gamma spectroscopy in March 1995, both in situ and at an off-site laboratory to determine whether they represented natural background or were the result of scattered DU. It was determined that the only DU anomalies within the SWMU 10 boundaries were in Mounds 3 and 6; the radioactive area seen in Mound 7 and other anomalies were of natural origin (i.e., the natural rock and soil types). The anthropogenic anomalies were removed during the VCM conducted in April 1996 (see Section 3.4.4.2.1).

3.4.3.1.4 *Cultural-Resources Survey*

A cultural-resources survey was conducted as part of the site assessment. One archeological site was identified north of SWMU 10, outside of the site boundary (Hoagland and Dello-Russo February 1995).

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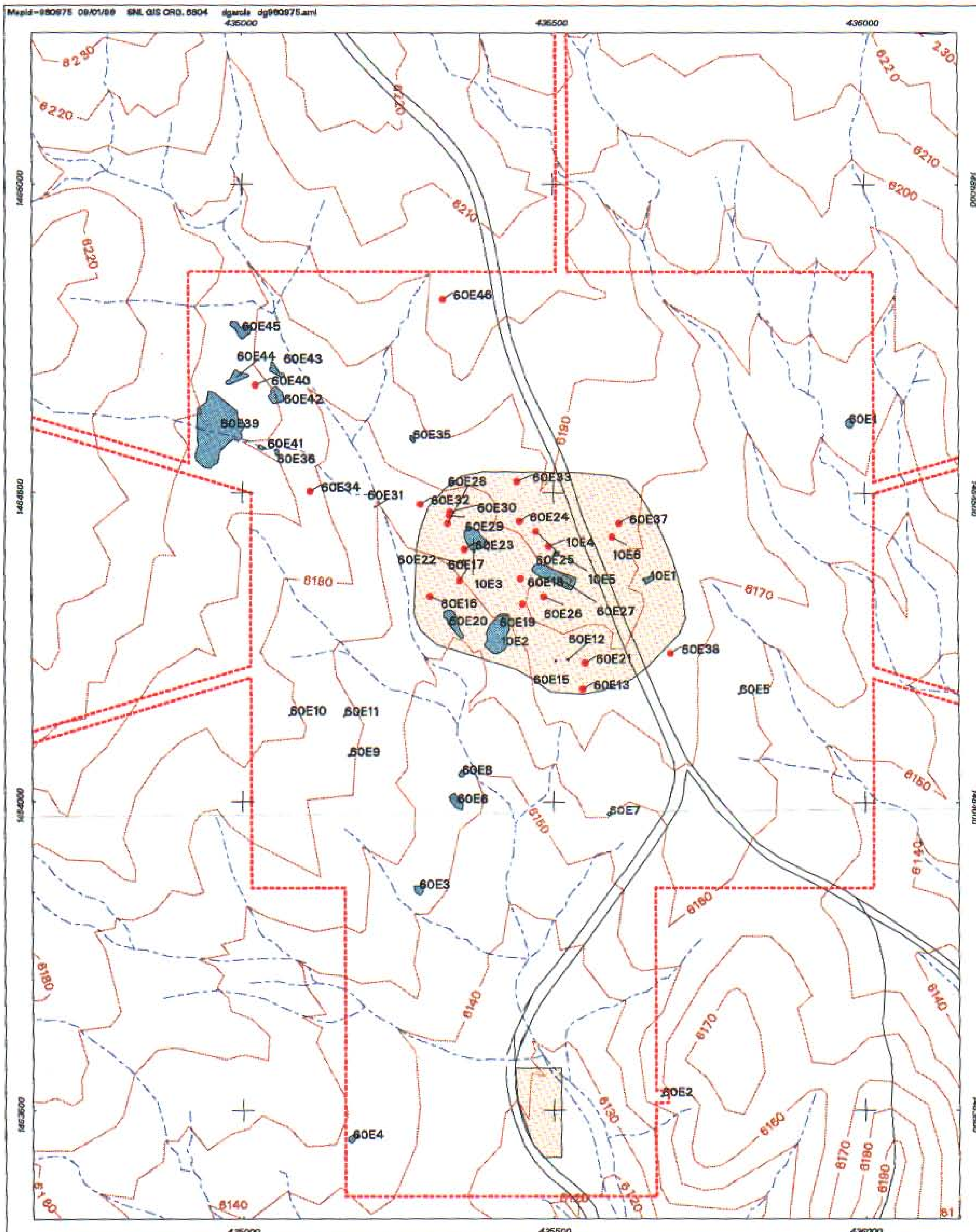

Legend

60E10 Point Source Radiation Anomaly

10 Ft Contour

Road

Surface Drainage

Survey Boundary

SWMU 10/60

Area Source Radiation Anomaly

Figure 3.4.3-1
Phase I Surface Radiation Survey at SWMU 10, Burial Mounds

0 175 350
Scale in Feet

0 40 80
Scale in Meters

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Environmental Geographic Information System

3.4.3.1.5 Sensitive-Species Survey

The site was surveyed for sensitive species on April 26 and May 24, 1994, using parallel transects spaced 100 feet apart (IT February 1995). The area is within piñon-juniper woodland vegetation, with an understory dominated by blue grama. The terrain is rolling, and the soil is coarse to rocky. A small but vigorous population of visnagita cacti was found on a low hill in the southeastern quarter of SWMU 10 near its outer boundary. A single Wright's pincushion cactus was found in the northeastern quarter of the survey area outside of the site boundary.

3.4.3.1.6 Geophysical Survey(s)

No geophysical surveys were performed at SWMU 10.

3.4.3.2 Sampling Data Collection

Scoping samples were collected in March 1995 and around SWMU 10 to determine whether radiological anomaly areas also contained RCRA-regulated hazardous constituents (e.g., metals, explosives compounds, etc.). Eight soil samples were collected: four from inside the site boundaries, and four from just outside the boundaries to serve as background samples. Semiquantitative results were produced using x-ray fluorescence and direct current plasma for metals and HE and using gamma spectroscopy for radiological constituents. Gamma spectroscopy revealed elevated anthropogenic radionuclides from four samples from within the site boundary, which were identified for removal during the VCM.

A follow-up scoping sampling was conducted in August 1995, to verify possible metals contamination indicated by the semiquantitative results obtained during the initial scoping sampling effort. Five samples were collected from Mounds 3 and 6 and were analyzed off site for metals and HE compounds using SNL/NM sample collection procedures. Figure 3.4.3-2 shows the follow-up scoping sample locations. Lockheed Analytical Services (LAS) of Las Vegas, Nevada, analyzed the samples for RCRA metals plus beryllium (using EPA Methods 6010/7000 [EPA November 1986]), and for HE (using EPA Method 8330 [EPA November 1986]). No quality assurance (QA)/quality control (QC) samples were collected.

3.4.3.3 Data Gaps

Information gathered from process knowledge, site files, and personal interviews aided in identifying the most likely COCs, the most likely locations of potential COC releases, and the types of analyses to be performed on soil samples. Radiological surveys and scoping sampling further defined the location and extent of contamination that exists at SWMU 10. However, because the need to remove elevated concentrations of radiological contamination was identified, residual contamination levels that would remain after such cleanup activities could not be defined.

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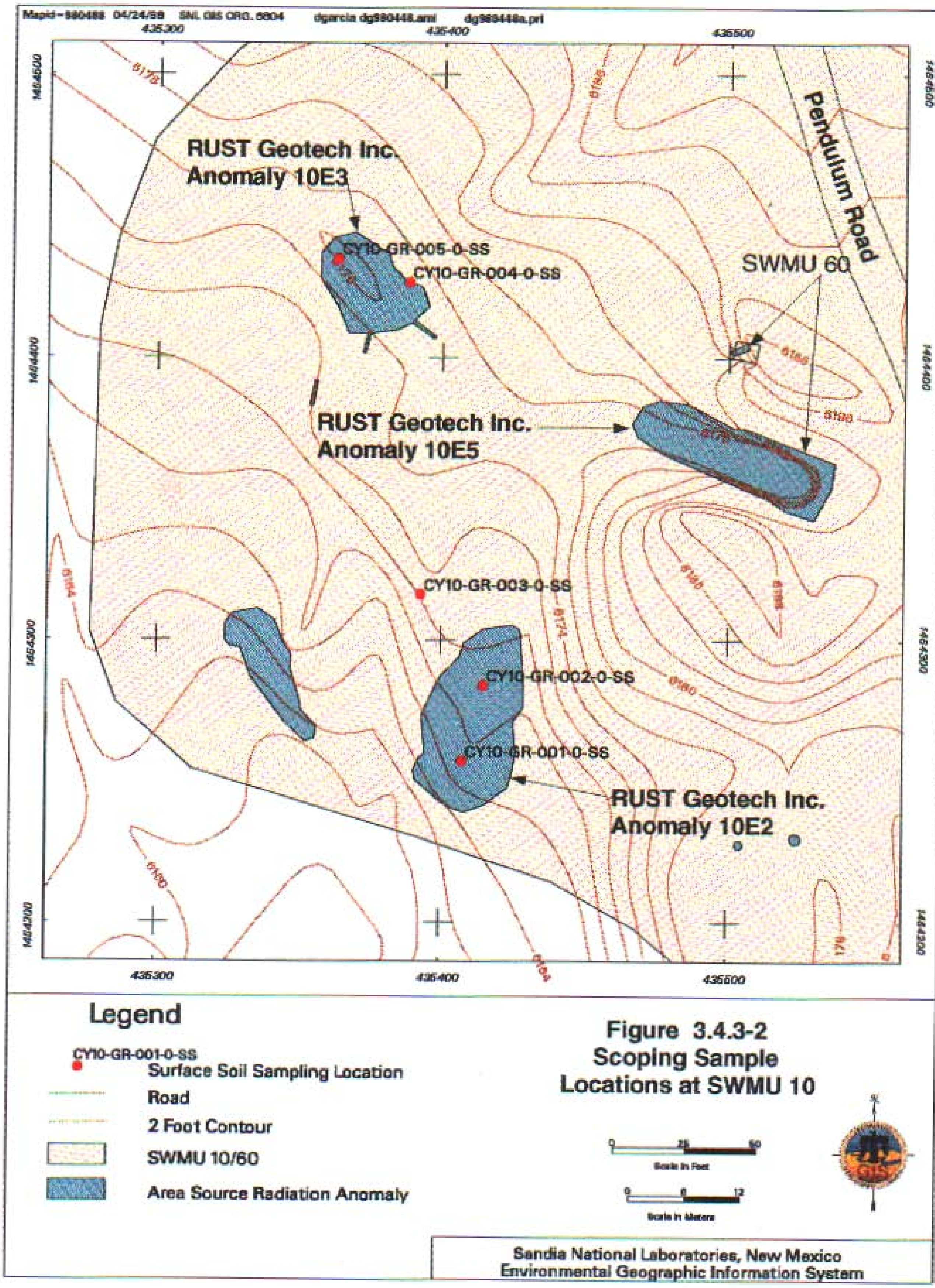

Figure 3.4.3-2
Scoping Sample Locations at SWMU 10

3.4.3.4 *Results and Conclusions*

Table 3.4.3-1 summarizes the off-site metals and HE analysis results for the five surface soil samples collected from Mounds 3 and 6 during follow-up scoping sampling at SWMU 10. Arsenic, barium, and lead were not detected above background concentrations. Mercury, selenium, and silver were not detected above their respective method detection limits (MDL). Beryllium concentrations were significantly elevated above background in both mounds. In addition, cadmium and chromium concentrations were detected above background in both mounds. No HE compounds were detected above practical quantitation limits.

<u>Data Validation</u>

The SNL/NM Sample Management Office reviewed and verified/validated all scoping sampling laboratory results as set forth by "Data Verification/Validation Level 2—DV-2" in Attachment B of Technical Operating Procedure 94-03, Rev. 0 (SNL/NM July 1994b). The verification/validation process confirmed that the data are acceptable for use in this NFA proposal for SWMU 10.

3.4.4 Investigation #3—SNL/NM ER Project Voluntary Corrective Measure and Confirmatory Sampling

3.4.4.1 *Nonsampling Data Collection*

There were no nonsampling data collection activities associated with the VCM and confirmatory sampling at SWMU 10.

3.4.4.2 *Sampling Data Collection*

A VCM was performed in April 1996 to remove all remaining area source gamma radiation anomalies occurring in the soil/debris mounds at SWMU 10. Confirmatory soil sampling was conducted following the VCM to confirm that no RCRA metals (plus beryllium), HE, or gamma-emitting radionuclides remained at the site at concentrations that might pose a level of risk under current and projected future land use.

3.4.4.2.1 *Voluntary Corrective Measures Activities*

Because there were recorded radiation area source anomalies at SWMU 10 that were not addressed during the initial Phase I radiological survey and cleanup (Section 3.4.3.1.3), SNL/NM executed a VCM to remove and dispose of the anomalies. The VCM, conducted in

Table 3.4.3-1
Summary of SWMU 10 Scoping Soil Sampling Metals and HE Analytical Results, August 1995
(Off-site laboratory only)

Sample Attributes			Metals (EPA Methods 6010/7000)[a] (mg/kg)									
Record Number[b]	ER Sample ID (Figure 3.4.3-2)	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	HE (EPA 8330)[a] (µg/g)
03951	CY10-GR-001-0-SS (Mound 6)	0–0.5	3.7	140	**5.1**[c]	**1.2**	**28**	12	ND (0.10) N	ND (0.98)	ND (2.0)	ND (0.25-2.2)
03951	CY10-GR-002-0-SS (Mound 6)	0–0.5	3.8	140	**2.1**	ND (0.99)	**19**	11	ND (0.10) N	ND (0.99)	ND (2.0)	ND (0.25-2.2)
03951	CY10-GR-003-0-SS (Mound 6)	0–0.5	3.9	130	**1.0**	ND (1.0)	13	8.1	ND (0.10) N	ND (1.0)	ND (2.0)	ND (0.25-2.2)
03951	CY10-GR-004-0-SS (Mound 3)	0–0.5	2.8	100	**13.0**	**1.9**	**29**	13	ND (0.10) N	ND (1.0)	ND (2.0)	ND (0.25-2.2)
03951	CY10-GR-005-0-SS (Mound 3)	0–0.5	3.8	170	**5.2**	**1.3**	**31**	12	ND (0.10) N	ND (0.99)	ND (2.0)	ND (0.25-2.2)
SNL/NM Canyons Soil Background 95th UTL or 95th-Percentile Concentrations[d]			9.8	246	0.75	0.64	18.8	18.9	0.055	3.0	<0.5	NA

[a]EPA November 1986.
[b]Analysis request/chain-of-custody record.
[c]Values in bold exceed background soil concentrations.
[d]From Zamorski December 1997.

CY = Canyon.
EPA = U.S. Environmental Protection Agency.
ER = Environmental restoration.
ft = Foot (feet).
GR = Grab sample.
HE = High explosives.
ID = Identification.
µg/g = Microgram(s) per gram.
mg/kg = Milligram(s) per kilogram.
N = Matrix spike recovery exceeded acceptance limits.
NA = Not applicable.
ND ( ) = Not detected at or above the project reporting limit for metals (shown in parenthesis) or the practical quantitation limit for HE (range shown in parenthesis).
SNL/NM = Sandia National Laboratories, New Mexico.
SS = Surface soil sample.
SWMU = Solid waste management unit.
UTL = Upper tolerance limit.

April 1996, involved trenching through all of the soil/debris mounds (except Mound 9), screening for radiological anomalies, and removing radioactive fragments and soil as necessary.

It had been shown during previous SWMU 10 radiation surveys (see Section 3.4.3.1.3) that Mounds 1, 2, 7, 8, and 10 have no anomalous radioactive surface contamination. However, during the VCM these mounds were investigated to confirm that no radioactive materials existed beneath the surface. Trenches were excavated through the mounds and the sidewalls and floor, and the areas were scanned for elevated radiation. It was verified that each of these mounds have no radioactive anomalies.

It had also been demonstrated during previous SWMU 10 radiation surveys (see Section 3.4.3.1.3) that Mounds 3 and 6 contained radioactive anomalies. In addition, it was discovered that two other mounds (Mounds 4 and 5) originally thought to have been free of radioactive material did contain radioactive anomalies. All four of these mounds were dissected by trenching, and the excavated materials were systematically screened for radioactive materials (i.e., material that exceeded 1.3 times background radiation readings). The radioactive materials (fragments and soil) were placed into 55-gallon drums for off-site disposal. The segregated clean soil was placed into *clean residual mounds* (Figures 3.4.4-1a and b). SNL/NM Department 7577 (Waste Operations) personnel handled and packaged these materials and secured the waste containers for transport and disposal at Envirocare of Utah (SNL/NM September 1997). A total of one hundred 55-gallon drums and one 30-gallon drum of contaminated soil and two 30-gallon drums of metals fragments were generated during the VCM (SNL/NM September 1997). Only clean soil (gamma radiation reading less than 1.3 times background) was left on site.

Although, because of its large extent and because it was not shown to contain radioactive anomalies, Mound 9 was not trenched during the course of the VCM. It was trenched through the interior to native soil in 3 locations during the subsequent confirmatory sampling investigation conducted in April 1997 (Section 3.4.4.2.2). The results of the VCM are summarized in the report entitled "Final Report, Survey and Removal of Radioactive Surface Contamination at Environmental Restoration Sites, Sandia National Laboratories/New Mexico" (SNL/NM September 1997).

3.4.4.2.2 Confirmatory Sampling

SNL/NM conducted confirmatory soil sampling between April and August 1997 to determine whether potential COCs were present at levels exceeding background limits at the site and/or were sufficient to pose a level of risk under current and projected future land uses. The confirmatory soil sampling program was performed in accordance with the rationale and procedures described in the "Sampling and Analysis Plan [SAP] for SWMU 10, Burial Mounds" (SNL/NM January 1997) and in the document of understanding related to the sampling (NMED DOE OB April 1997). Both of these documents were developed in close consultation with New Mexico Environment Department (NMED) DOE Oversight Bureau personnel. All mounds were trenched in multiple locations to the undisturbed soil surface. All samples were grab samples collected using a stainless steel bowl and scoop or trowel, in accordance with ER Field Operating Procedure 94-52 (SNL/NM January 1995). For all sampling activities that included a

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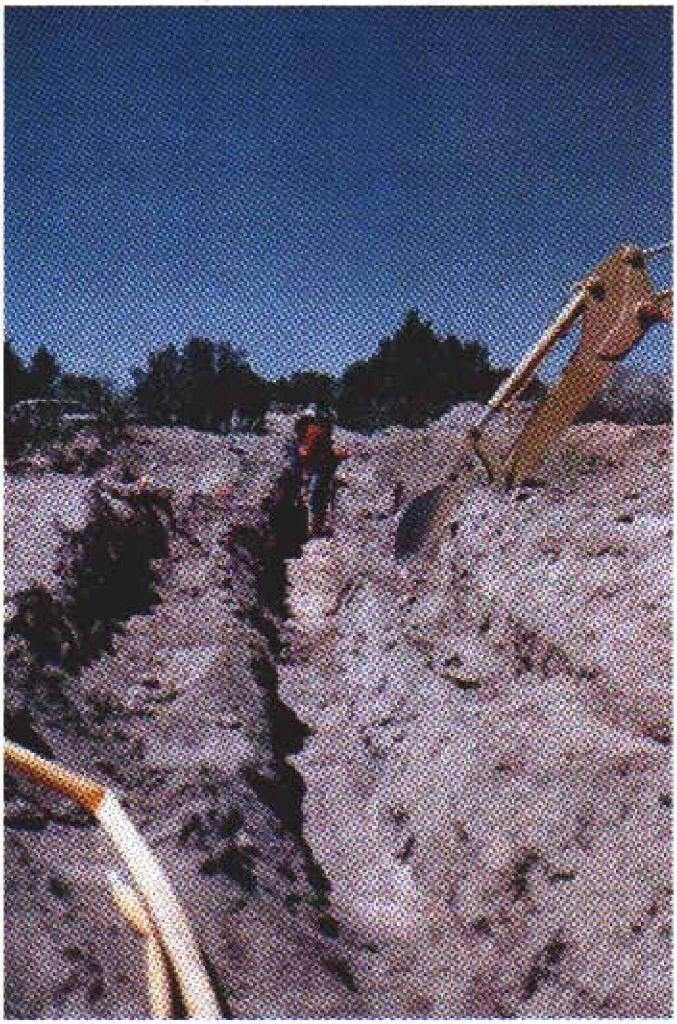

Figure 3.4.4-1a. Longitudinal trench through Mound 6 (north view).

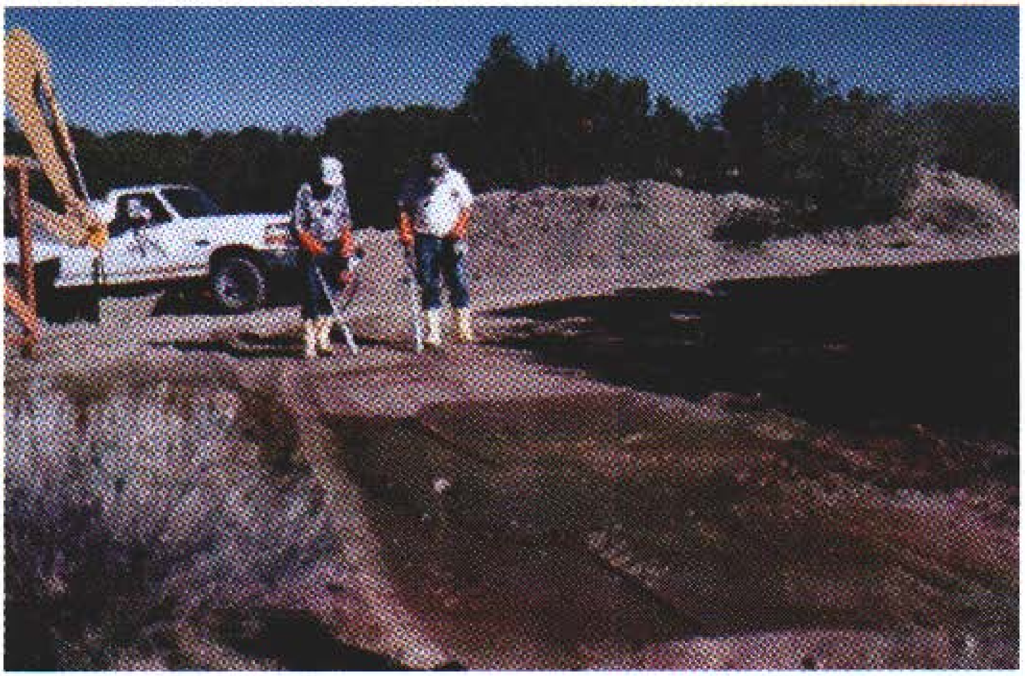

Figure 3.4.4-1b. Layout pad for spreading and screening material from Mound 5 (north view).

combination of judgmental and random sampling, SNL/NM adhered to the SAP with only minor modification in the field.

The number of trenches excavated at each soil debris mound ranged from one to three depending upon the soil/debris mound size and material consistency. Trench soil samples were collected from the middle of each sidewall and trench bottom beneath the soil/debris mound and native soil interface. Judgmental soil samples were collected from adjacent arroyos (sediment storage areas) and from trenches excavated through the mounds; random samples were collected from the surface in a radial grid pattern representing the fragmentation radius at the point of weapons detonation. Figure 3.4.4-2 shows both the confirmatory sample collection locations in the mounds and the radial grid. Figure 3.4.4-3 shows the confirmatory sample collection locations in the arroyos.

Fifty samples were collected from the mounds at depths of approximately 1 to 2 feet from the top and 1 foot below the bottom of the mound. Seven samples were collected from the arroyos at a depth of 0.5-foot bgs. Seventeen near-surface samples were collected from the radial grid at a depth of 0.5-foot bgs. SNL/NM followed analysis request/chain-of-custody (AR/COC) and sample documentation procedures for all samples collected. All samples were analyzed on site for RCRA metals plus beryllium, HE, and gamma-emitting radionuclides. SNL/NM Department 6684 (ER Chemistry Laboratory) analyzed the samples on site for RCRA metals plus beryllium using EPA Method 6020 (EPA November 1986) and for HE using a micellar electrokinetic chromatograph. SNL/NM Department 7713 (Radiation Protection Sample Diagnostics Laboratory) analyzed the samples on site for radionuclides using gamma spectroscopy. SNL/NM on-site laboratories analyzed QA/QC samples (rinsates and duplicates), which were collected at the rate of 1 in 10. In addition, approximately 15 percent of the samples were split for analysis at an off-site laboratory, including duplicate soil sample analyses. LAS of Las Vegas, Nevada, analyzed the samples for RCRA metals plus beryllium using EPA Method 6010/7000 and for HE using EPA Method 8330 (EPA November 1986).

As indicated in Section 3.4.4.4.1, Mound 9 was investigated as part of the confirmatory sampling performed at SWMU 10. The mound was dissected by trenches 3 feet wide by 4 feet deep that were cut approximately north-south, northwest-southeast, and northeast-southwest (approximately 60, 35, and 35 feet long, respectively) (Figure 3.4.4-4). One small piece of oxidized DU (schoepite) was detected in the toe of the southeast-trending trench, but no other DU was detected in any of the trenches through Mound 9.

During the sampling activities conducted at the mounds, a single sample was collected from a surface water collection area located at the base of the soil berm adjacent to Mound 9. Although not intended for surface water collection, accumulation of surface water occurs because of the location of the soil berm relative to the local topography. A sample was collected from this area based on the potential accumulation of surficial contamination migrating in surface water. The sample collected from this area is identified as CY10-PIT-1.

3.4.4.3 Data Gaps

Information gathered from process knowledge, historical site files, and personal interviews aided in identifying the most likely COCs at SWMU 10 and in selecting the types of analyses to be performed on soil samples. Although the history of past releases at the site is incomplete,

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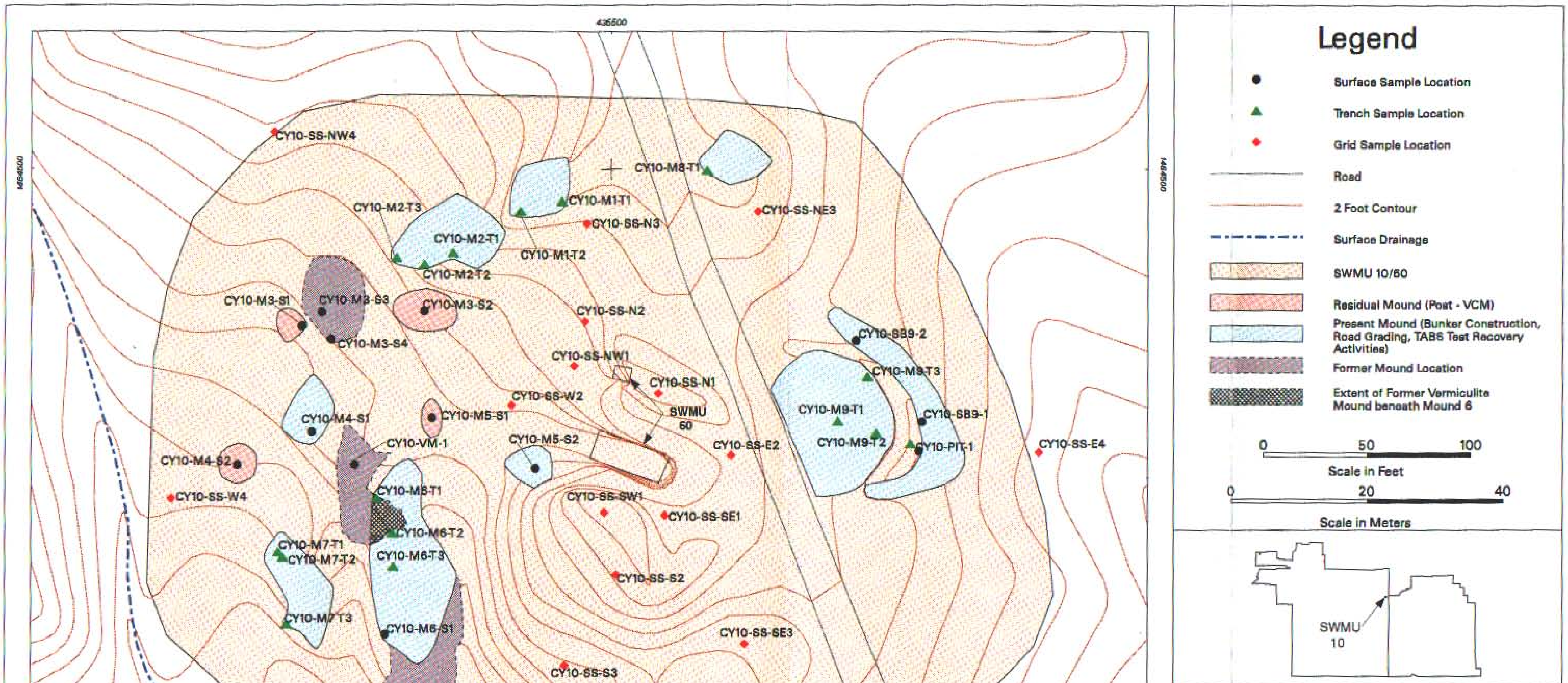

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Figure 3.4.4-2
Confirmatory Sample Locations for the Mounds and Grid at SWMU 10

	1:600	MAPID= 980976
Unclassified	DRAFT	SNL GIS ORG. 6804
SMorrison	sm980936.aml	08/05/98

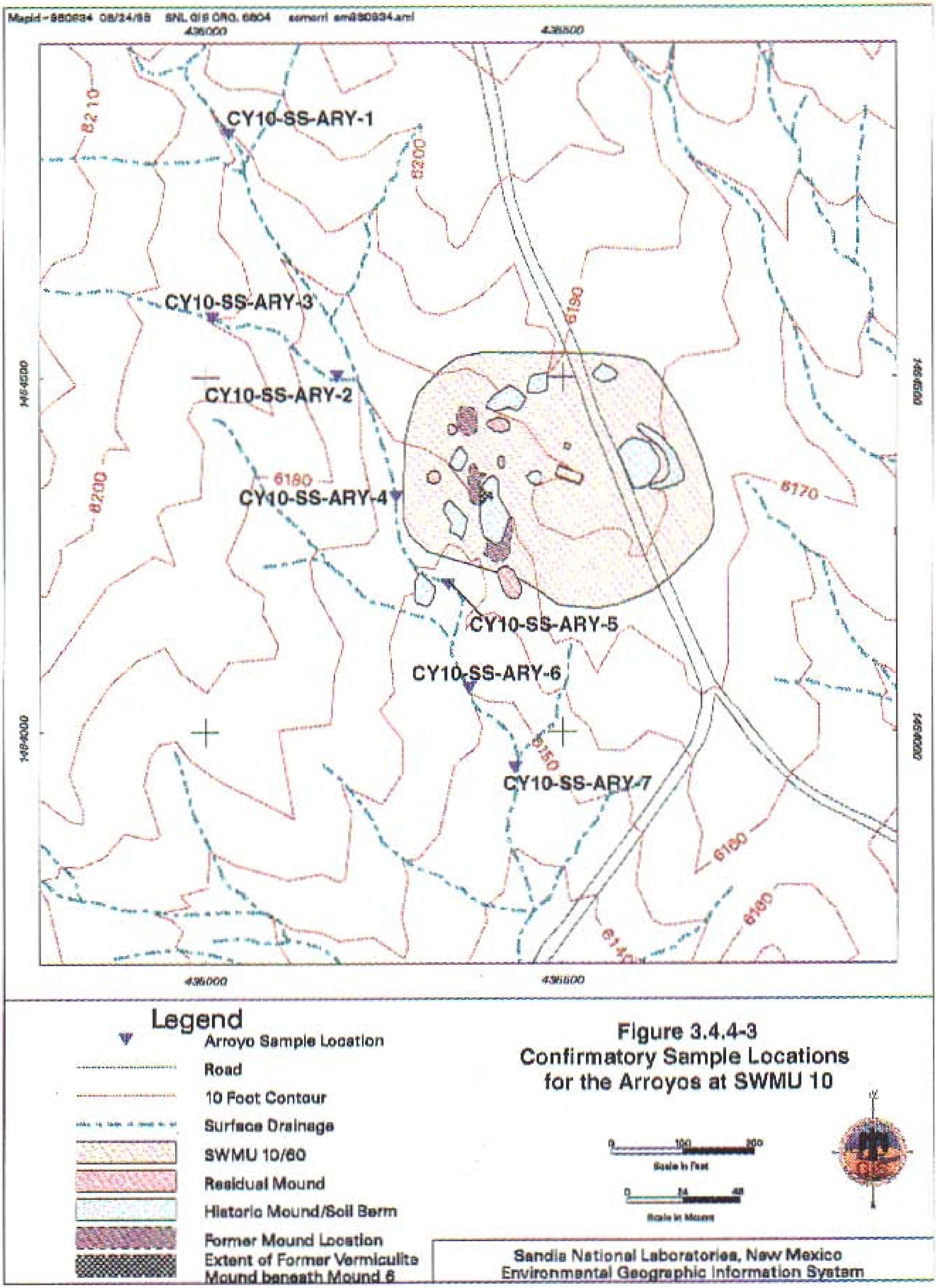

Figure 3.4.4-3
Confirmatory Sample Locations for the Arroyos at SWMU 10

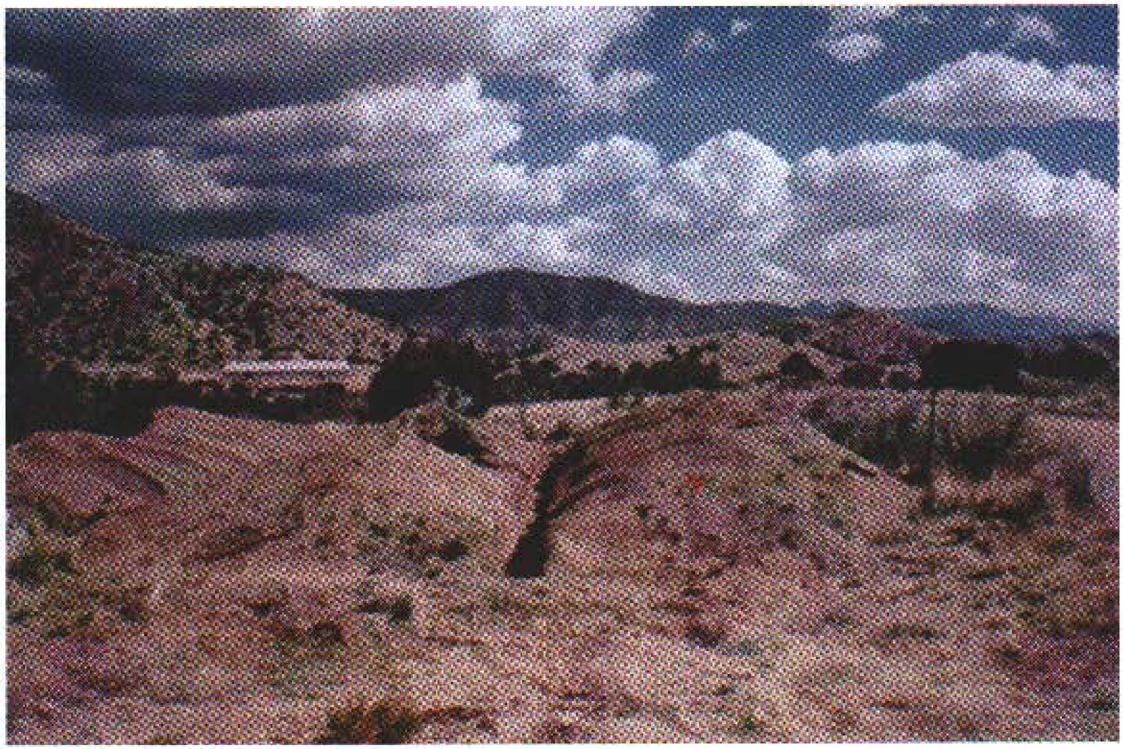

Figure 3.4.4-4. Northwest to southeast trench in Mound 9 (southeast view).

analytical data from confirmatory sampling are sufficient to determine whether significant releases of COCs occurred at the site.

3.4.4.4 *Results and Conclusions*

The following sections summarize the analytical results for characterizing the soil mounds, fragmentation area (Grid Sampling), and the arroyo sediment.

3.4.4.4.1 *Soil Mounds*

Tables 3.4.4-1 and 3.4.4-2 list the on- and off-site metal analysis and gamma spectroscopy analysis results, respectively, for the 53 soil samples, 5 split samples, and 5 duplicates collected from the soil mounds during confirmatory sampling at SWMU 10. Table 3.4.4-3 summarizes the HE compounds analyzed for and their respective MDLs. This section summarizes the analytical results.

<u>Metals</u>

Concentrations of arsenic were not detected above the background limit in any of the samples. Concentrations of cadmium and selenium were detected slightly above the background limit in only one sample (CY10-PIT-1D). Concentrations of silver were detected above the nonquantified background limit of <0.5 milligram (mg) per kilogram (/kg) in two samples (CY10-PIT-1 and duplicate).

The beryllium concentration in sample CY10-M3-S1 (3.4 mg/kg) was elevated nearly five times the 0.75 mg/kg background limit but was also observed in the method blank. However, the beryllium concentration in the duplicate of sample CY10-M3-S1 that was analyzed on site was below the background limit. Other samples in which beryllium concentrations were detected above background include CY10-M3-S2, CY10-M6-T3-M, CY10-M6-S2, CY10-M8-T1-B, CY10-M9-T1-M, CY10-M9-T2-B, CY10-M9-T3-M, CY10-PIT-1 (including the split [analyzed off site], duplicate, and split duplicate [analyzed off site]), and CY10-M10-T3-M. The concentration of beryllium in these samples is less than twice the background limit. All other samples contained beryllium at or below the background limit.

Lead concentrations were only slightly above background in sample CY10-PIT-1, including the split (analyzed off site), duplicate, and split duplicate (analyzed off site). All other post-VCA (vermiculite mound removal) samples contained lead at or below the background limit. The mercury concentrations in several samples (including CY10-M1-T2-B, CY10-M2-T1-M, and CY10-PIT-1 [and duplicate]) were estimated to be at levels slightly exceeding the 0.055 mg/kg background concentration limit. Although mercury was not detected in any of the samples analyzed off site, the MDL used for these analyses were above the background limit. Mercury was not detected in the remaining samples and the detection limits were below background.

Concentrations of both barium and chromium were significantly higher than the background limits in several samples collected from locations either within or near the vermiculite mound that existed prior to the VCA. As described in Annex 3-A of this NFA, this outcome is believed

Table 3.4.4-1
Summary of SWMU 10 Confirmatory Soil Sampling Metal Analytical Results, Soil Mounds, April–August 1997

Sample Attributes			Metals (EPA 6010/6020/7000)[a] (mg/kg)								
Record Number[h]	ER Sample ID (Figure 3.4.4-2)	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
06157	CY10-M1-T1-M	0.5–1.0	1.6 J (2.6)	100	0.51 B	0.18	4.6	3.5	ND (0.044)	0.74 J (1.3)	ND (0.044)
06157	CY10-M1-T1-B	0.5–1.0	1.1 J (2.6)	81	0.41 B	0.1 J (0.18)	5.2	2.7	ND (0.044)	0.62 J (1.3)	ND (0.044)
06157	CY10-M1-T2-M	0.5–1.0	1.3 J (2.9)	110	0.5 B	0.099 J (0.2)	**20**[c]	3.1	ND (0.049)	0.77 J (1.5)	ND (0.049)
06157	CY10-M1-T2-B	0.5–1.0	1.7 J (3)	180	0.66 B	0.21	**37**	4.8	**0.075 J (0.2) B**	1.7	ND (0.05)
06543	CY10-M2-T1-M (Off-site laboratory)	0.5–1.0	3.9	130	0.67 J (0.82)	ND (0.33)	**40.**	7.9	ND (0.11)	ND (0.66)	ND (0.33)
06157	CY10-M2-T1-M	0.5–1.0	1.8 J (2.8)	140	0.74 B	0.23	**21**	7.4	**0.066 J (0.19) B**	1.2 J (1.4)	ND (0.047)
06157	CY10-M2-T1-B	0.5–1.0	1.3 J (2.8)	130	0.58 B	0.15 J (0.18)	8.5	5.9	0.047 J (0.18) B	1 J (1.4)	ND (0.046)
06157	CY10-M2-T2-M	0.5–1.0	1.6 J (2.6)	140	0.65 B	0.2	18	5	ND (0.044)	1.3	ND (0.044)
06157	CY10-M2-T2-B	0.5–1.0	1.6 J (2.9)	120	0.54 B	0.17 J (0.2)	18	5	ND (0.049)	1.2 J (1.5)	ND (0.049)
06157	CY10-M2-T3-M	0.5–1.0	0.71 J (2.4)	75	0.6 B	0.18	15	3.8	ND (0.04)	1 J (1.2)	0.071 J (0.16)
06157	CY10-M2-T3-B	0.5–1.0	1.9 J (2.7)	110	0.56 B	0.19	18	3.6	ND (0.045)	1.2 J (1.3)	ND (0.045)
06157	CY10-M3-S1	0.5–1.0	1.7 J (2.4)	140	**3.4 B**	0.43	18	7.7	ND (0.04)	1 J (1.2)	0.11 J (0.16)
06157	CY10-M3-S1-D	0.5–1.0	1.3 J (2.6)	87	0.72	0.2	12	4.5	ND (0.044)	0.9 J (1.3)	0.083 J (0.17)
06157	CY10-M3-S2	0.5–1.0	1.8 J (2.8)	130	**1**	0.31	**26**	6.6	0.055 J (0.19) B	1.3 J (1.4)	0.1 J (0.19)
06157	CY10-M3-S3	0.5–1.0	1.2 J (2.8)	72	0.54	0.18 J (0.19)	8.3	5	ND (0.047)	0.58 J (1.4)	0.076 J (0.19)
06008	CY10-M3-S4	0.5–1.0	1.9 J (2.6)	99	0.59 B	0.16 J (0.18) B	5.6	6.2	ND (0.044)	0.88 J (1.3)	ND (0.044)
06157	CY10-M4-S1 (Pre-VCA)	0.5–1.0	0.87 J (2.4)	**550 E**	**0.83**	0.14 J (0.16)	**290 E**	6.4	**0.064 J (0.16) B**	0.69 J (1.2)	0.092 J (0.16)
06543	CY10-M4-S2 (Pre-VCA) (Off-site laboratory)	0.5–1.0	3.7	**590**	0.68 J (1.0)	ND (0.40)	**350**	14.	ND (0.11)	ND (0.81)	ND (0.40)
06543	CY10-M4-S2-D (Pre-VCA) (Off-site laboratory)	0.5–1.0	2.9	**550**	0.57 J (0.93)	ND (0.37)	**340**	16.	ND (0.11)	0.91 J (0.93)	ND (0.37)
06157	CY10-M4-S2 (Pre-VCA)	0.5–1.0	1.1 J (2.7)	**540 E**	0.59	0.16 J (0.18)	**260 E**	12	ND (0.045)	0.62 J (1.4)	0.063 J (0.18)
06157	CY10-M4-S2-D (Pre-VCA)	0.5–1.0	1 J (2.7)	**350 E**	0.47	0.15 J (0.18)	**160**	9.8	ND (0.046)	0.62 J (1.4)	0.065 J (0.18)
06566	CY10-VM-1 (Pre-VCA) (Off-site laboratory)	0.5–1.0	3.5	**410**	0.69 J (0.87)	ND (0.35)	**170**	**27.**	ND (0.11)	ND (0.70)	ND (0.35)
06008	CY10-VM-1 (Pre-VCA)	0.5–1.0	ND (0.62)	180 B	0.55 B	0.18 B	**72**	18	ND (0.041)	0.87 J (1.2)	ND (0.041)
600316	CY10-052698-GR-001-SS (Post-VCA) (Off-site laboratory)		2.69	93.9	0.586	0.164	6.53	6.25	ND (0.173)	0.894	ND (0.031)

Refer to footnotes at end of table.

Table 3.4.4-1 (Continued)
Summary of SWMU 10 Confirmatory Soil Sampling Metal Analytical Results, Soil Mounds, April–August 1997

Sample Attributes			Metals (EPA 6010/6020/7000)[a] (mg/kg)								
Record Number[b]	ER Sample ID (Figure 3.4.4-2)	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
600316	CY10-052698-GR-001-DU (Post-VCA) (Off-site laboratory)		2.64	101	0.490	0.125	7.12	6.90	ND (0.173)	0.779	ND (0.031)
600316	CY10-052698-GR-002-SS (Post-VCA) (Off-site laboratory)		2.79	94.0	0.479	0.146	6.40	5.01	ND (0.173)	0.783	ND (0.031)
06157	CY10-M5-S1	0.5–1.0	1.2 J (3)	97	0.64	0.16 J (0.2)	**23**	6.1	ND (0.05)	0.96 J (1.5)	ND (0.05)
06157	CY10-M5-S2	0.5–1.0	1.2 J (2.5)	79	0.67 B	0.22 B	15	7.2	ND (0.041)	0.91 J (1.2)	0.049 J (0.16)
06566	CY10-M6-T1-M (Off-site laboratory)	0.5–1.0	4.0	100	0.54 J (1.0)	ND (0.42)	12.	6.4	ND (0.11)	ND (0.84)	ND (0.42)
06008	CY10-M6-T1-M	0.5–1.0	2.7	120	0.5 B	0.15 J (0.18) B	14	6.8	ND (0.046)	0.73 J (1.4)	ND (0.046)
06008	CY10-M6-T1-M-D	0.5–1.0	2.8 J (2.9)	120	0.49 B	0.14 J (0.2) B	6	6.9	ND (0.049)	0.56 J (1.5)	ND (0.049)
06566	CY10-M6-T1-M-D (Off-site laboratory)	0.5–1.0	4.2	120	0.56 J (1.1)	ND (0.42)	15.	7.0	ND (0.11)	ND (0.84)	ND (0.42)
06008	CY10-M6-T1-B	1.0–1.5	1.7 J (3)	92	0.59 B	0.14 J (0.2) B	5.7	6.4	ND (0.049)	0.7 J (1.5)	ND (0.049)
06008	CY10-M6-T2-M	0.5–1.0	1.6 J (2.8)	200	0.73 B	0.24 B	**44**	16	ND (0.046)	1.3 J (1.4)	0.053 J (0.18) B
06008	CY10-M6-T2-B	1.0–1.5	2.2 J (2.8)	95	0.42 B	0.11 J (0.19) B	4	5.6	ND (0.047)	0.59 J (1.4)	ND (0.047)
06008	CY10-M6-T3-M	0.5–1.0	1.3 J (3)	100	**0.78 B**	0.29 B	7.1	7.6	ND (0.051)	2.1	0.24B
06008	CY10-M6-T3-B	1.0–1.5	0.99 J (2.5)	77	0.56 B	0.15 J (0.17) B	7	5.4	ND (0.042)	0.78 J (1.2)	ND (0.042)
06008	CY10-M6-S1	0.5–1.0	1.7 J (2.8)	100	0.53 B	0.15 J (0.19) B	5.9	6.3	ND (0.048)	0.71 J (1.4)	ND (0.048)
06008	CY10-M6-S2	0.5–1.0	1.2 J (2.8)	100	**0.82 B**	0.24 B	11	8	ND (0.047)	1.2 J (1.4)	0.076 J (0.19) B
06008	CY10-M7-T1-M	0.5–1.0	1.3 J (2.5)	100	0.71 B	0.27 B	16	10	ND (0.042)	1.3	0.073 J (0.17) B
06008	CY10-M7-T1-B	1.0–1.5	0.99 J (2.7)	71	0.64	0.19	14	5.1	ND (0.044)	1.2 J (1.3)	0.053 J (0.18)
06008	CY10-M7-T2-M (Pre-VCA)	0.5–1.0	0.96 J (2.9)	**480 E**	0.74	0.21	**180**	7.1	ND (0.048)	0.98 J (1.4)	0.26
06008	CY10-M7-T2-B	1.0–1.5	0.78 J (2.8)	140	0.58	0.16 J (0.19)	**45**	8.5	ND (0.047)	0.83 J (1.4)	0.072 J (0.19)
06008	CY10-M7-T3-M	0.5–1.0	1.8 J (2.6)	55	0.75	0.28	8.9	12	ND (0.044)	1.5	0.092 J (0.17)
06008	CY10-M7-T3-B	1.0–1.5	0.93 J (2.6)	64	0.58	0.2	6.2	9.2	ND (0.043)	1.3	ND (0.043)
06008	CY10-M8-T1-M	0.5–1.0	2.2 J (2.9)	96	0.52	0.17 J (0.2)	6.4	7.5	ND (0.049)	0.86 J (1.5)	ND (0.049)
06008	CY10-M8-T1-B	1.0–1.5	1 J (2.4)	62	**0.78 B**	0.43 B	6.7	9.2	ND (0.039)	2	0.1 J (0.16) B
06566	CY10-M9-T1-M (Off-site laboratory)	0.5–1.0	4.0	110	0.71 J (1.0)	ND (0.41)	9.8	7.0	ND (0.11)	ND (0.83)	ND (0.41)
06566	CY10-M9-T1-M-D (Off-site laboratory)	0.5–1.0	3.8	110	0.62 J (1.0)	ND (0.40)	8.8	6.0	ND (0.096)	ND (0.80)	ND (0.40)
06008	CY10-M9-T1-M	0.5–1.0	2.3 J (2.5)	200	**0.81 B**	0.26 B	7.6	8.4	ND (0.042)	2	ND (0.042)

Refer to footnotes at end of table.

Table 3.4.4-1 (Continued)
Summary of SWMU 10 Confirmatory Soil Sampling Metal Analytical Results, Soil Mounds, April–August 1997

Sample Attributes			Metals (EPA Method 6010/6020/7000)[a] (mg/kg)								
Record Number[b]	ER Sample ID (Figure 3.4.4-2)	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
06008	CY10-M9-T1-M-D	0.5–1.0	1.9 J (2.4)	150	0.73 B	0.19 B	6.4	7.7	ND (0.039)	1.4	ND (0.039)
06008	CY10-M9-T1-B	1.0–1.5	1.4 J (2.4)	130	0.71 B	0.29 B	8	6.4	ND (0.04)	2.2	ND (0.04)
06008	CY10-M9-T2-M	0.5–1.0	2.2 J (2.4)	150	0.75 B	0.23 B	7	10	ND (0.041)	1.6	0.044 J (0.16) B
06008	CY10-M9-T2-B	1.0–1.5	1.7 J (2.4)	140	**0.78 B**	0.22 B	8.5	7.9	ND (0.04)	1.6	ND (0.04)
06008	CY10-M9-T3-M	0.5–1.0	1.8 J (2.4)	150	**1.1 B**	0.34 B	9.5	16	ND (0.04)	2	0.055 J (0.16) B
06008	CY10-M9-T3-B	1.0–1.5	1.2 J (2.5)	150	0.62	0.21	5.2	6.6	ND (0.042)	1.3	ND (0.042)
06542	CY10-PIT-1 (Off-site laboratory)	0.5–1.0	8.7	**250**	**1.3**	ND (0.46)	18.	**20.**	ND (0.13)	ND (0.92)	ND (0.46)
06542	CY10-PIT-1D (Off-site laboratory)	0.5–1.0	8.6	**250**	**1.2**	ND (0.41)	17.	**19.**	ND (0.12)	ND (0.81)	ND (0.41)
06159	CY10-PIT-1	0.5–1.0	4.6	230	**1.1**	0.6	12	**20**	**0.066 J (0.22)**	2.9	**0.61**
06159	CY10-PIT-1D	0.5–1.0	4.6	240 E	**1.2**	**0.65**	14	**20**	**0.068 J (0.19)**	**3.1**	**0.57**
06159	CY10-SB9-1	0.5–1.0	1.4 J (2.3)	96	0.51	0.22	6	6.4	ND (0.038)	1 J (1.1)	ND (0.038)
06159	CY10-SB9-2	0.5–1.0	0.9 J (2.9)	120	0.46	0.25	5.8	4.5	ND (0.048)	1.4	ND (0.048)
06008	CY10-M10-T1-M	0.5–1.0	ND (0.6)	68	0.41	0.083 J (0.16)	2.2 J (2.8)	4.4	ND (0.04)	ND (0.3)	ND (0.04)
06566	CY10-M10-T1-B (Off-site laboratory)	1.0–1.5	4.0	87.	0.67 J (1.1)	ND (0.42)	14.	7.2	ND (0.11)	ND (0.84)	ND (0.42)
06566	CY10-M10-T1-B-D (Off-site laboratory)	1.0–1.5	3.6	71.	0.58 J (1.0)	ND (0.41)	11.	6.5	ND (0.11)	ND (0.82)	ND (0.41)
06008	CY10-M10-T1-B	1.0–1.5	1.4 J (2.5)	100	0.67	0.2	8.8	8.8	ND (0.042)	0.75 J (1.2)	ND (0.042)
06008	CY10-M10-T1-B-D	1.0–1.5	0.96 J (2.6)	67	0.47	0.16 J (0.17)	5.2	5.1	ND (0.044)	0.65 J (1.3)	ND (0.044)
06008	CY10-M10-T2-M	0.5–1.0	1.6 J (2.7)	110	0.71	0.3	8	11	ND (0.045)	0.81 J (1.4)	ND (0.045)
06008	CY10-M10-T2-B	1.0–1.5	0.9 J (2.6)	68 B	0.49 B	0.15 J (0.17) B	5.8	6.9	ND (0.043)	0.39 J (0.13)	ND (0.043)
06008	CY10-M10-T3-M	0.5–1.0	1.8 J (2.6)	140 B	**0.87 B**	0.3 B	9	10	ND (0.044)	0.83 J (1.3)	0.073 J (0.18) B
06008	CY10-M10-T3-B	1.0–1.5	1.8 J (2.4)	92 B	0.66 B	0.23 B	8.4	8.1	ND (0.041)	0.68 J (1.2)	ND (0.041)
Quality Assurance/Quality Control Samples (all in µg/L)											
06157	CY10-RBA (EB)	NA	ND (0.67)	ND (0.79)	ND (0.022)	ND (0.045)	ND (1.7)	ND (0.34)	ND (0.045)	ND (0.34)	ND (0.045)
06008	CY10-RBC (EB)	NA	ND (3.4)	ND (3.9)	ND (0.11)	ND (0.22)	ND (8.4)	ND (1.7)	ND (0.22)	ND (1.7)	ND (0.22)
06008	CY10-RBD (EB)	NA	ND (3.4)	ND (3.9)	ND (0.11)	ND (0.22)	ND (8.4)	ND (1.7)	ND (0.22)	ND (1.7)	ND (0.22)
06008	CY10-RBE (EB)	NA	ND (3.4)	ND (3.9)	ND (0.11)	ND (0.22)	ND (8.4)	ND (1.7)	ND (0.22)	ND (1.7)	ND (0.22)
SNL/NM Canyons Soil Background 95th UTL or 95th Percentile Concentrations[d]			9.8	246	0.75	0.64	18.8	18.9	0.055	3.0	<0.5

Refer to footnotes at end of table.

Table 3.4.4-1 (Concluded)
Summary of SWMU 10 Confirmatory Soil Sampling Metal Analytical Results, Soil Mounds, April–August 1997

[a]EPA Method 6020 (EPA November 1986) used by on-site laboratory and EPA Methods 6010/7000 (EPA November 1986) used by off-site laboratory.
[b]Analysis request/chain of custody record.
[c]Values in bold exceed background soil concentrations.
[d]From Zamorski December 1997.

B = Associated analyte was also observed in the method blank.
CY = Canyon.
E = The associated concentration was observed above the highest calibration level.
EB = Equipment blank.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
ft = Foot (feet).
ID = Identification.
J ( ) = The estimated value reported is either above the method detection limit (MDL) and less than the practical quantification limit (shown in parentheses) for on-site laboratory analyses or above the instrument detection limit and less than the contract required detection limit (shown in parentheses) for off-site laboratory analyses.

µg/L = Microgram(s) per liter.
mg/kg = Milligram(s) per kilogram.
NA = Not applicable.
ND ( ) = Not detected at or above the MDL, shown in parenthesis.
SNL/NM = Sandia National Laboratories, New Mexico.
SWMU = Solid waste management unit.
UTL = Upper tolerance limit.

Table 3.4.4-2
Summary of SWMU 10 Confirmatory Soil Sampling Gamma Spectroscopy Analysis, Soil Mounds, April–August 1997

Sample Attributes			Activity (pCi/g)							
			Uranium-238		Thorium-232		Uranium-235		Cesium-137	
Record Number[a]	ER Sample ID (Figure 3.4.4-1)	Sample Depth (ft)	Result	Error[b]	Result	Error[b]	Result	Error[b]	Result	Error[b]
06546	CY10-M1-T1-M	0.5–1.0	**4.59E+00**[c]	3.91E+00	**1.10E+00**	5.43E-01	1.19E-01	1.79E-01	3.91E-02	2.76E-02
06546	CY10-M1-T1-B	0.5–1.0	1.36E+00	1.22E+00	**1.05E+00**	5.02E-01	**2.38E-01**	1.73E-01	4.43E-02	2.18E-02
06546	CY10-M1-T2-M	0.5–1.0	ND (1.11E+00)	--	**1.25E+00**	5.90E-01	1.31E-01	1.79E-01	ND (4.70E-02)	--
06546	CY10-M1-T2-B	0.5–1.0	ND (1.68E+00)	--	**1.10E+00**	5.23E-01	ND (2.35E-01)	--	ND (4.41E-02)	--
06544	CY10-M2-T1-M	0.5–1.0	ND (2.09E+00)	--	**1.21E+00**	5.57E-01	**1.61E-01**	1.91E-01	1.32E-01	6.72E-02
06546	CY10-M2-T1-B	0.5–1.0	ND (1.69E+00)	--	**1.16E+00**	1.03E+00	ND (2.39E-01)	--	ND (2.60E-02)	--
06546	CY10-M2-T2-M	0.5–1.0	ND (1.68E+00)	--	**1.10E+00**	5.24E-01	ND (2.30E-01)	--	2.60E-01	1.06E-01
06546	CY10-M2-T2-B	0.5–1.0	ND (1.68E+00)	--	**1.11E+00**	5.28E-01	ND (2.24E-01)	--	5.82E-02	2.49E-02
06546	CY10-M2-T3-M	0.5–1.0	2.06E+00	1.31E+00	**1.22E+00**	5.67E-01	ND (2.21E-01)	--	ND (4.07E-02)	--
06546	CY10-M2-T3-B	0.5–1.0	ND (1.74E+00)	--	9.41E-01	1.49E+00	ND (1.52E-01)	--	1.58E-02	1.35E-02
06544	CY10-M3-S1	0.5–1.0	**8.41E+00**	2.22E+00	**1.20E+00**	5.76E-01	**2.91E-01**	1.66E-01	2.68E-02	1.75E-02
06544	CY10-M3-S1-D	0.5–1.0	**5.92E+00**	1.76E+00	**1.05E+00**	4.86E-01	4.93E-02	7.54E-02	3.30E-02	1.73E-02
06546	CY10-M3-S2	0.5–1.0	**7.43E+00**	5.44E+00	1.02E+00	4.78E-01	**2.25E-01**	1.15E-01	2.44E-02	1.93E-02
06546	CY10-M3-S3	0.5–1.0	**2.63E+00**	3.18E+00	9.66E-01	4.51E-01	**1.24E-01**	1.23E-01	6.04E-02	2.30E-02
06575	CY10-M3-S4	0.5–1.0	ND (1.70E+00)	--	9.72E-01	4.92E-01	ND (2.31E-01)	--	ND (4.18E-02)	--
06546	CY10-M4-S1	0.5–1.0	ND (3.45E+00)	--	9.25E-01	4.37E-01	ND (2.52E-01)	--	2.69E-02	2.60E-02
06544	CY10-M4-S2	0.5–1.0	ND (1.53E+00)	--	8.60E-01	4.30E-01	ND (2.16E-01)	--	2.04E-01	6.93E-02
06544	CY10-M4-S2-D	0.5–1.0	ND (2.08E+00)	--	7.80E-01	3.75E-01	1.07E-01	1.85E-01	2.49E-01	5.12E-02
03350	CY10-VM-1	0.5–1.0	1.15E+00	9.23E-01	**1.22E+00**	5.75E-01	1.04E-01	1.76E-01	ND (4.48E-02)	--
06546	CY10-M5-S1	0.5–1.0	ND (3.33E+00)	--	**1.13E+00**	5.31E-01	ND (2.45E-01)	--	ND (3.30E-02)	--
06546	CY10-M5-S2	0.5–1.0	**2.31E+00**	1.94E+00	9.37E-01	4.66E-01	ND (2.43E-01)	--	6.26E-02	3.24E-02
03350	CY10-M6-T1-M	0.5–1.0	ND (1.68E+00)	--	8.28E-01	4.01E-01	ND (2.26E-01)	--	ND (4.01E-02)	--
06575	CY10-M6-T1-B	1.0–1.5	ND (1.78E+00)	--	9.79E-01	4.69E-01	ND (2.37E-01)	--	ND (4.34E-02)	--
06575	CY10-M6-T2-M	0.5–1.0	1.55E+00	1.08E+00	9.86E-01	4.85E-01	8.94E-02	9.61E-02	3.74E-02	5.17E-02
06575	CY10-M6-T2-B	1.0–1.5	ND (1.79E+00)	--	8.30E-01	9.92E-01	ND (2.39E-01)	--	ND (4.41E-02)	--
06575	CY10-M6-T3-M	0.5–1.0	1.11E+00	1.74E+00	**1.29E+00**	6.08E-01	**1.20E-01**	9.15E-02	3.16E-02	1.68E-02
06575	CY10-M6-T3-B	1.0–1.5	1.46E+00	9.83E-01	8.80E-01	4.34E-01	ND (1.01E-01)	--	ND (4.05E-02)	--
06575	CY10-M6-S1	0.5–1.0	1.17E+00	8.69E-01	**1.21E+00**	5.70E-01	ND (2.32E-01)	--	2.80E-02	2.12E-02
06575	CY10-M6-S2	0.5–1.0	**2.92E+00**	--	9.58E-01	4.64E-01	6.81E-02	7.25E-02	ND (4.66E-02)	--
06575	CY10-M7-T1-M	0.5–1.0	ND (1.97E+00)	--	**1.46E+00**	7.25E-01	ND (2.71E-01)	--	2.99E-01	4.12E-01
06575	CY10-M7-T1-B	1.0–1.5	ND (1.92E+00)	--	**1.57E+00**	7.44E-01	8.72E-02	1.02E-01	5.43E-02	2.58E-02
06575	CY10-M7-T2-M	0.5–1.0	ND (1.31E+00)	--	**1.21E+00**	5.79E-01	**1.60E-01**	1.88E-01	5.38E-01	9.45E-02
06575	CY10-M7-T2-B	1.0–1.5	ND (1.61E+00)	--	9.40E-01	4.57E-01	ND (2.28E-01)	--	6.37E-02	2.64E-02
06575	CY10-M7-T3-M	0.5–1.0	ND (1.92E+00)	--	**1.43E+00**	6.71E-01	ND (2.64E-01)	--	ND (5.05E-02)	--
06575	CY10-M7-T3-B	1.0–1.5	ND (1.85E+00)	--	**1.47E+00**	7.01E-01	ND (2.57E-01)	--	ND (4.75E-02)	--

Refer to footnotes at end of table.

Table 3.4.4-2 (Concluded)
Summary of SWMU 10 Confirmatory Soil Sampling Gamma Spectroscopy Analysis, Soil Mounds, April–August 1997

Sample Attributes			Activity (pCi/g)							
			Uranium-238		Thorium-232		Uranium-235		Cesium-137	
Record Number[a]	ER Sample ID (Figure 3.4.4-1)	Sample Depth (ft)	Result	Error[b]	Result	Error[b]	Result	Error[b]	Result	Error[b]
06575	CY10-M8-T1-M	0.5–1.0	8.40E-01	9.11E-01	9.67E-01	5.00E-01	ND (2.36E-01)	--	ND (4.12E-02)	--
06575	CY10-M8-T1-B	1.0–1.5	ND (3.73E+00)	--	**1.13E+00**	5.24E-01	ND (2.72E-01)	--	ND (3.60E-02)	--
03350	CY10-M9-T1-M-D	0.5–1.0	ND (1.73E+00)	--	**1.09E+00**	6.57E-01	ND (2.45E-01)	--	ND (4.51E-02)	--
06575	CY10-M9-T1-M	0.5–1.0	ND (3.45E+00)	--	**1.10E+00**	5.86E-01	ND (2.51E-01)	--	2.65E-02	1.38E-02
06575	CY10-M9-T1-B	1.0–1.5	ND (3.51E+00)	--	**1.15E+00**	5.18E-01	ND (2.59E-01)	--	ND (3.49E-02)	--
06575	CY10-M9-T2-B	1.0–1.5	1.66E+00	9.51E-01	1.01E+00	1.10E+00	**2.34E-01**	1.53E-01	2.42E-02	1.47E-02
06570	CY10-M9-T2-U	0.5–1.0	**3.47E+00**	1.01E+00	**1.05E+00**	5.02E-01	ND (2.25E-01)	--	ND (4.48E-02)	--
06575	CY10-M9-T3-M	0.5–1.0	ND (3.43E+00)	--	**1.09E+00**	5.17E-01	ND (2.50E-01)	--	ND (3.31E-02)	--
06575	CY10-M9-T3-B	1.0–1.5	ND (3.39E+00)	--	9.90E-01	4.61E-01	ND (2.45E-01)	--	2.20E-02	1.72E-02
06544	CY10-PIT-1	0.5–1.0	ND (3.15E+00)	--	**2.29E+00**	1.04E+00	1.39E-01	1.30E-01	3.36E-01	7.47E-02
06544	CY10-PIT-1-D	0.5–1.0	ND (2.35E+00)	--	**2.27E+00**	1.06E+00	**3.03E-01**	2.38E-01	ND (3.73E-02)	--
06546	CY10-SB9-1	0.5–1.0	ND (3.70E+00)	--	1.00E+00	4.68E-01	ND (2.69E-01)	--	1.36E-01	4.13E-02
06546	CY10-SB9-2	0.5–1.0	ND (2.88E+00)	--	**1.14E+00**	5.65E-01	ND (2.14E-01)	--	ND (2.92E-02)	--
06575	CY10-M10-T1-M	0.5–1.0	5.48E-01	6.39E-01	6.68E-01	3.26E-01	ND (1.89E-01)	--	ND (3.54E-02)	--
03350	CY10-M10-T1-B	0.5–1.0	ND (1.59E+00)	--	**1.06E+00**	4.99E-01	ND (2.22E-01)	--	ND (4.01E-02)	--
06575	CY10-M10-T2-M	0.5–1.0	ND (4.06E+00)	--	**1.34E+00**	8.73E-01	ND (2.98E-01)	--	ND (3.94E-02)	--
06575	CY10-M10-T2-B	1.0–1.5	ND (3.38E+00)	--	1.02E+00	4.78E-01	ND (2.44E-01)	--	ND (3.16E-02)	--
06575	CY10-M10-T3-M	0.5–1.0	ND (1.61E+00)	--	1.00E+00	4.99E-01	ND (2.24E-01)	--	ND (4.25E-02)	--
06575	CY10-M10-T3-B	1.0–1.5	ND (1.41E+00)	--	1.00E+00	4.72E-01	ND (2.06E-01)	--	ND (3.89E-02)	--
Quality Assurance/Quality Control Samples (all in pCi/mL)										
06546	CY10-RBA (EB)	NA	ND (1.73E+00)	--	ND (1.56E-01)	--	ND (1.60E-01)	--	ND (2.24E-02)	--
06575	CY10-RBC (EB)	NA	ND (9.68E-01)	--	ND (1.79E-01)	--	ND (1.53E-01)	--	ND (3.15E-02)	--
06575	CY10-RBD (EB)	NA	ND (2.01E+00)	--	ND (1.73E-01)	--	ND (1.77E-01)	--	ND (2.60E-02)	--
06575	CY10-RBE (EB)	NA	ND (7.98E-01)	--	ND (1.58E-01)	--	ND (1.42E-01)	--	ND (2.52E-02)	--
Background Soil Activity, Lower Canyons[d]			2.31	NA	1.03	NA	0.16	NA	1.55	NA

[a]Analysis request/chain of custody record.
[b]Two standard deviations about the mean detected activity.
[c]Values in bold exceed background soil activity.
[d]From Dinwiddie September 1997.

CY = Canyon.
EB = Equipment blank.
ER = Environmental Restoration.
ft = Foot (feet).
ID = Identification.
NA = Not applicable.

ND ( ) = Not detected at or above the minimum detectable activity, shown in parenthesis.
pCi/g = Picocurie(s) per gram.
pCi/mL = Picocurie(s) per milliliter.
SNL/NM = Sandia National Laboratories, New Mexico.
SWMU = Solid waste management unit.
-- = Error not calculated for nondetectable results.

Table 3.4.4-3
Summary of HE Analysis Detection Limits
Used for SWMU 10 Confirmatory Soil Sampling, April—August 1997

HE Compounds	Analysis Detection Limits	
	On-Site Analyses by MEKC (mg/kg)	Off-Site Analyses by EPA Method 8330[a] (μg/g)
1,3,5-trinitrobenzene	0.093–0.12	0.070
1,3-dinitrobenzene	0.065–0.085	0.10
2,4,6-trinitrotoluene	0.25–0.33	0.11
2,4-dinitrotoluene	0.21–0.28	0.16
2,6-dinitrotoluene	0.25–0.33	0.19
2-amino-4,6-dinitrotoluene	0.11–0.14	0.13
2-nitrotoluene	0.13–0.17	0.070
3-nitrotoluene	0.13–0.17	0.16
4-amino-2,6-dinitrotoluene	0.093–0.12	0.055
4-nitrotoluene	0.11–0.14	0.17
HMX	0.11–0.14	0.42
Nitrobenzene	0.15–0.19	0.15
Pentaerythritol tetranitrate	0.3–0.39	NA
RDX	0.16–0.2	0.19
Tetryl	NA	0.34

[a]EPA November 1986.
EPA = U.S. Environmental Protection Agency.
HE = High explosives.
HMX = 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane.
MEKC = Micellar electrokinetic chromatography.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
RDX = 1,3,5-trinitro-1,3,5-triazacyclohexane.
SWMU = Solid waste management unit.
Tetryl = 2,4,6-trinitrophenylmethylnitramine.
μg/g = Microgram(s) per gram.

to be a result of the chemical composition of vermiculite, which was present in the sample matrices, rather than an indication of environmental contamination. However, barium slightly exceeded background at sample locations not necessarily within or near the former vermiculite mound (CY10-PIT-1 split and split duplicate). Chromium exceeded background in one or more samples collected from Mounds 1 through 7, including sample location CY10-PIT-1.

Radionuclides

Table 3.4.4-2 presents a summary of the on-site gamma spectroscopy results for the 50 soil samples and 4 duplicate samples collected during confirmatory sampling at SWMU 10. Annex 3-B contains complete results of the gamma spectroscopy analyses. Gamma activity from uranium-238 is equivalent to or exceeds the 2.31 picocuries per gram (pCi/g) background limit in samples CY10-M1-T1-M, CY10-M3-S1 and duplicate, CY10-M3-S2, CY10-M3-S3, CY10-M5-S2, CY10-M6-S2, and CY10-M9-T2-U. The detected uranium-238 activity ranged from 0.55 pCi/g to 8.41 pCi/g. The uranium-238 activity is residual from the mock weapon detonation. Gamma activity from uranium-238 was not detected in 13 other samples in which the minimum detectable activity (MDA) exceeded the background concentration.

Thorium-232 is a long-lived thorium series indicator for contamination (Miller June 1998). Gamma activity from thorium-232 exceeded background in 31 samples. Thirty-one out of fifty soil samples only slightly exceeded background, sample CY10-PIT-1 and the duplicate were about twice the background activity.

Gamma activity resulting from uranium-235 was detected equivalent to or slightly above the 0.16 pCi/g background limit in samples CY10-M1-T1-B, CY10-M2-T1-M, CY10-M3-S2, CY10-M3-S3, CY10-M6-T3-B, CY10-M7-T2-M, and CY10-M9-T2-B. Gamma activity from uranium-235 was also detected above background in sample CY10-M3-S1 but not in the duplicate sample CY10-M3-S1-D. Conversely, gamma activity from uranium-235 was detected above background in the duplicate sample CY10-PIT-1-D but not in sample CY10-PIT-1. Gamma activity resulting from cesium-137 was not detected above the 1.55 pCi/g background limit in any of the samples collected.

Explosives

During confirmatory sampling at SWMU 10, a total of 50 soil samples, 12 split samples, and 6 duplicate samples were collected from the soil mounds and analyzed for HE. Results of the analyses indicate that HE compounds were not detected in any of the samples. Table 3.4.4-3 shows the detection limits used for HE analyses by both on- and off-site laboratories.

3.4.4.4.2 Fragmentation Area—Grid Soil Sampling

Tables 3.4.4-4 and 3.4.4-5 summarize the on- and off-site metals analysis and gamma spectroscopy analysis results, respectively, for the 17 soil samples and 1 duplicate sample collected from the radial grid pattern covering the fragmentation area during confirmatory sampling at SWMU 10. Table 3.4.4-3 lists the HE compounds analyzed for and their respective

Table 3.4.4-4
Summary of SWMU 10 Confirmatory Soil Sampling Metal Analytical Results, Grid Sampling, April–August 1997

Sample Attributes			Metals (EPA Methods 6010/6020/7000)[a] (mg/kg)								
Record Number[b]	ER Sample ID (Figure 3.4.4-2)	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
06158	CY10-SS-N2	0.5–1.0	1.4 J (2.7)	76 B	**0.79 B**[c]	0.28 B	7.3	9.2	ND (0.045)	1.3	0.05 J (0.18) B
06158	CY10-SS-N3	0.5–1.0	1.7 J (2.7)	87 B	**0.92 B**	0.24 B	7.5	16	ND (0.046)	1.4	ND (0.046)
06158	CY10-SS-NE1	0.5–1.0	1.3 J (2.5)	140 B	**0.77 B**	0.25 B	7.4	9	ND (0.042)	1.4	ND (0.042)
06158	CY10-SS-NE3	0.5–1.0	1.2 J (2.6)	110 B	0.73 B	0.26 B	5.3	6.7	ND (0.043)	1.5	0.046 J (0.17) B
06158	CY10-SS-E2	0.5–1.0	1.6 J (2.3)	99 B	0.62 B	0.2 B	7.4	7.5	ND (0.039)	0.58 J (1.2)	ND (0.039)
06158	CY10-SS-E4	0.5–1.0	3.5	110 B	0.69 B	0.26 B	9.6	**30**	ND (0.039)	0.95 J (1.3)	ND (0.039)
06158	CY10-SS-SE1	0.5–1.0	ND (0.67)	76 B	0.6 B	0.21 B	4.6	6	ND (0.045)	0.94 J (1.3)	ND (0.045)
06158	CY10-SS-SE3	0.5–1.0	1 J (2.7)	120 B	**0.92 B**	0.26 B	5.3	7.1	ND (0.046)	1.7	ND (0.046)
06158	CY10-SS-S2	0.5–1.0	1.3 J (2.7)	100	0.68 B	0.22 B	17	8.8	ND (0.045)	1.2 J (1.4)	0.052 J (0.18) B
06567	CY10-SS-S3 (Off-site laboratory)	0.5–1.0	4.7	120	**0.82 J (0.98)**	ND (0.39)	12.	9.8	ND (0.11)	ND (0.78)	ND (0.39)
06567	CY10-SS-S3-D (Off-site laboratory)	0.5–1.0	3.5	91.	0.65 J (0.93)	ND (0.37)	13.	7.9	ND (0.11)	ND (0.75)	ND (0.37)
06158	CY10-SS-S4	0.5–1.0	1.9 J (2.3)	160	**0.95 B**	0.26 B	8.6	12	ND (0.039)	1 J (1.2)	0.062 J (0.16) B
06158	CY10-SS-SW1	0.5–1.0	0.89 J (2.3)	73	0.72 B	0.21 B	5.4	7	ND (0.038)	1.1 J (1.2)	ND (0.038)
06158	CY10-SS-SW4	0.5–1.0	2.7	140	**0.94 B**	0.26 B	10	10	ND (0.046)	1 J (1.4)	ND (0.046)
06158	CY10-SS-W2	0.5–1.0	0.86 J (2.3)	75	0.73 B	0.26 B	7.1	7.4	ND (0.039)	1.2	0.066 J (0.16) B
06158	CY10-SS-W4	0.5–1.0	1 J (2.7)	83	0.71	0.24	7.2	8.7	ND (0.045)	1.1 J (1.4)	0.1 J (0.18)
06158	CY10-SS-NW1	0.5–1.0	1.4 J (2.8)	110	0.71	0.22	9.6	8.1	ND (0.046)	1.1 J (1.4)	ND (0.046)
06158	CY10-SS-NW4	0.5–1.0	0.76 J (2.6)	44	**0.83**	0.32	5	7.9	ND (0.044)	0.91 J (1.3)	0.17
Quality Assurance/Quality Control Sample (in µg/L)											
06158	CY10-RBG (EB)	NA	ND (3.4)	ND (3.9)	ND (0.11)	ND (0.22)	ND (8.4)	ND (1.7)	ND (0.22)	ND (1.7)	ND (0.22)
SNL/NM Canyons Soil Background 95th UTL or 95th-Percentile Concentrations[d]			9.8	246	0.75	0.64	18.8	18.9	0.055	3.0	<0.5

[a]EPA Method 6020 (EPA November 1986) used by on-site laboratory and EPA Methods 6010/7000 (EPA November 1986) used by off-site laboratory.

[b]Analysis request/chain of custody record.

[c]Values in bold exceed background soil concentrations.

[d]From Zamorski December 1997.

B = Associated analyte was also observed in the method blank.
CY = Canyon.
D = Duplicate.
EB = Equipment blank.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
ft = Foot (feet).
ID = Identification.
J ( ) = The estimated value reported is either above the method detection limit (MDL) and less than the practical quantification limit (shown in parenthesis) for on-site laboratory analyses or above the instrument detection limit and less than the contract required detection limit (shown in parenthesis) for off-site laboratory analyses.

µg/L = Microgram(s) per liter.
mg/kg = Milligram(s) per kilogram.
NA = Not applicable.
ND ( ) = Not detected above the MDL (shown in parenthesis).
SNL/NM = Sandia National Laboratories, New Mexico.
SS = Surface soil sample.
SWMU = Solid waste management unit.
UTL = Upper tolerance limit.

Table 3.4.4-5

Summary of SWMU 10 Confirmatory Soil Sampling Gamma Spectroscopy Analysis, Grid Sampling, April–August 1997

Sample Attributes			Activity (pCi/g)							
			Uranium-238		Thorium-232		Uranium-235		Cesium-137	
Record Number[a]	ER Sample ID (Figure 3.4.4-2)	Sample Depth (ft)	Result	Error[b]	Result	Error[b]	Result	Error[b]	Result	Error[b]
06569	CY10-SS-N2	0.5–1.0	1.16E+00	1.01E+00	**1.07E+00**[c]	5.25E-01	ND (2.26E-01)	--	2.61E-02	1.89E-02
06569	CY10-SS-N3	0.5–1.0	ND (1.43E+00)	--	**1.20E+00**	5.80E-01	ND (2.30E-01)	--	9.10E-02	3.95E-02
06569	CY10-SS-NE1	0.5–1.0	ND (1.52E+00)	--	9.88E-01	6.63E-01	ND (2.15E-01)	--	ND (3.82E-02)	--
06569	CY10-SS-NE3	0.5–1.0	ND (1.52E+00)	--	8.71E-01	4.18E-01	ND (2.13E-01)	--	1.28E-01	5.72E-02
06569	CY10-SS-E2	0.5–1.0	ND (1.82E+00)	--	**1.39E+00**	6.67E-01	ND (2.45E-01)	--	2.81E-02	3.75E-02
06569	CY10-SS-E4	0.5–1.0	ND (1.62E+00)	--	8.36E-01	4.07E-01	ND (2.19E-01)	--	ND (4.21E-02)	--
06569	CY10-SS-SE1	0.5–1.0	ND (1.25E+00)	--	ND (2.17E-01)	--	ND (2.75E-01)	--	2.22E-02	2.29E-02
06569	CY10-SS-SE3	0.5–1.0	ND (1.61E+00)	--	**1.33E+00**	6.19E-01	ND (2.51E-01)	--	ND (4.73E-02)	--
06569	CY10-SS-S2	0.5–1.0	ND (1.47E+00)	--	**1.05E+00**	4.89E 01	ND (2.09E 01)	--	2.07E-02	1.33E-02
06568	CY10-SS-S3	0.5–1.0	ND (3.66E+00)	--	**1.13E+00**	5.26E-01	ND (2.66E-01)	--	3.51E-02	2.18E-02
06569	CY10-SS-S4	0.5–1.0	2.12E+00	1.66E+00	**1.18E+00**	5.55E-01	ND (2.20E-01)	--	ND (4.02E-02)	--
06569	CY10-SS-SW1	0.5–1.0	ND (1.54E+00)	--	**1.05E+00**	4.92E-01	ND (2.12E-01)	--	1.04E-01	1.98E-01
06569	CY10-SS-SW4	0.5–1.0	ND (1.49E+00)	--	**1.08E+00**	6.43E-01	ND (2.01E-01)	--	2.83E-02	1.78E-02
06569	CY10-SS-W2	0.5–1.0	1.73E+00	1.01E+00	**1.07E+00**	5.13E-01	ND (1.45E-01)	--	3.33E-02	1.89E-02
06569	CY10-SS-W4	0.5–1.0	ND (1.60E+00)	--	**1.06E+00**	5.09E-01	ND (2.26E-01)	--	1.15E-01	7.55E-02
06569	CY10-SS-NW1	0.5–1.0	ND (1.60E+00)	--	**1.10E+00**	5.17E-01	ND (2.27E-01)	--	5.19E-02	2.44E-02
06569	CY10-SS-NW4	0.5–1.0	ND (1.41E+00)	--	7.31E-01	3.72E-01	ND (1.91E-01)	--	4.44E-02	2.67E-02
Background Soil Activity, Lower Canyons[d]			2.31	NA	1.03	NA	0.16	NA	1.55	NA
Quality Assurance/Quality Control Sample (in pCi/mL)										
06569	CY10-RBG (EB)	NA	ND (8.96E-01)	--	ND (1.54E-01)	--	ND (1.46E-01)	--	ND (2.90E-02)	--

[a]Analysis request/chain of custody record.
[b]Two standard deviations about the mean detected activity.
[c]Values in bold exceed background soil activity.
[d]From Dinwiddie September 1997.

CY = Canyon.
EB = Equipment blank.
ER = Environmental Restoration.
ft = Foot (feet).
ID = Identification.
NA = Not applicable.
ND ( ) = Not detected at or above the minimum detectable activity, shown in parentheses.
pCi/g = Picocurie(s) per gram.
pCi/mL = Picocurie(s) per milliliter.
SNL/NM = Sandia National Laboratories, New Mexico.
SS = Surface soil sample.
SWMU = Solid waste management unit.
-- = Error not calculated for nondetectable results.

MDLs. This section summarizes the analytical results from the grid sampling in the fragmentation area.

Metals

Concentrations of arsenic, barium, cadmium, chromium, and selenium were not detected above background concentrations in any samples. Silver does not have a quantified background concentration. However, the maximum reported silver concentration is 0.61 mg/kg. Mercury was not detected in any of the 18 samples analyzed. However, samples CY10-SS-S3 and CY10-SS-S3-D were analyzed for mercury at the off-site laboratory, which used a detection limit of 0.11 mg/kg which exceeded the 0.055 mg/kg background limit. Lead concentration levels were elevated above the 18.9 mg/kg background limit in one sample (CY10-SS-E4). No other samples contained lead concentrations above background. Beryllium concentration levels were slightly elevated above the 0.75 mg/kg background limit in 8 of the 18 samples collected. However, none of the samples containing elevated beryllium concentrations were above 1.0 mg/kg.

Radionuclides

Table 3.4.4-5 summarizes the on-site gamma spectroscopy results for the 17 soil samples collected during confirmatory sampling at SWMU 10. Annex 3-B contains complete results of the gamma spectroscopy analyses. Gamma activity from uranium-238 does not exceed the 2.31 pCi/g background limit in any samples. However, the MDA used in the analysis of sample CY10-SS-S3 did exceed the background activity.

Thorium-232 is a long-lived thorium series indicator for contamination (Miller June 1998). Gamma activity from thorium-232 exceeded background limits in 12 samples. However, in each instance the background activity was exceeded only slightly.

Gamma activity resulting from uranium-235 was not detected in any of the 17 samples that were collected; however, the detection limits used for 16 of those samples were above the 0.16 pCi/g background level. Because gamma activity from uranium-238 and thorium-234 (Annex 3-B) were below background limits, it is reasonable to infer that uranium-235 also does not exceed background limits in these samples. In addition, the MDA for uranium-235 was still several orders of magnitude less than a projected preliminary remediation goal (PRG) for that isotope, so there is no human health or environmental concern. Gamma activity resulting from cesium-137 was not detected above the 1.55 pCi/g background limit in any of the samples collected.

Explosives

During confirmatory sampling at SWMU 10, a total of 17 surface soil samples and 1 duplicate sample were collected from the radial grid pattern and analyzed for HE. Results of the analyses show that HE compounds were not detected in the samples. Table 3.4.4-3 shows the detection limits used for HE analyses by both on- and off-site laboratories.

3.4.4.4.3 *Arroyo Sediment Sampling*

Tables 3.4.4-6 and 3.4.4-7 summarize the on- and off-site metals analysis and gamma spectroscopy analysis results, respectively, for the seven soil samples and one duplicate sample collected from the arroyo sediments during confirmatory sampling at SWMU 10. Table 3.4.4-3 summarizes the HE compounds analyzed for and their respective MDLs. A summary of the analytical results for all arroyo sediment samples are described below.

Metals

Concentrations of arsenic, barium, cadmium, lead, and selenium were not detected above background limits in any samples. Silver does not have a quantified background limit. However, the maximum reported silver concentration is 0.17 mg/kg. Mercury was not detected in any of the eight samples analyzed. However, samples CY10-SS-ARY-2 and the duplicate for CY10-SS-ARY-2 were analyzed for mercury at the off-site laboratory, which used a detection limit of 0.11 mg/kg, which exceeded the 0.055 mg/kg background limit. It was estimated that beryllium was slightly above the 0.75 mg/kg background limit in the sample duplicate for CY10-SS-ARY-2. No other samples contained beryllium above background.

Concentrations of chromium were elevated above the 18.8 mg/kg background limit in samples CY10-SS-ARY-2, the duplicate for CY10-SS-ARY-2, and CY10-SS-ARY-4. These sample locations are immediately adjacent to the former vermiculite mound. This outcome is believed to be a result of the chemical composition of vermiculite, which was present in the sample matrices, rather than an indication of environmental contamination (see Annex 3-A).

Radionuclides

Table 3.4.4-7 summarizes the on-site gamma spectroscopy results for the seven soil samples collected during confirmatory sampling at SWMU 10. Annex 3-B contains complete results of the gamma spectroscopy analyses. Gamma activity from uranium-238 for sample CY10-SS-ARY-4 was 7.51 pCi/g which exceeded the 2.31 pCi/g background activity limit. In addition, the MDA used in the analysis of sample CY10-SS-ARY-2 exceeded the background activity limit.

Thorium-232 is a long-lived thorium series indicator for contamination (Miller June 1998). Gamma activity from thorium-232 exceeded background limits in five samples. However, in each instance the background limits were exceeded only slightly.

Gamma activity resulting from uranium-235 was not detected above the 0.16 pCi/g background activity limit. However, the MDAs for six of the seven samples were above the background activity limit. Because gamma activity from uranium-238 was below background activity limits in six samples, it is reasonable to infer that uranium-235 also does not exceed background activity limits in those six samples. In addition, the MDA for uranium-235 was still several orders of magnitude less than a projected PRG for that isotope, so there is no human health or environmental concern. Gamma activity resulting from cesium-137 was not detected above the 1.55 pCi/g background limit in any of the samples collected.

Table 3.4.4-6
Summary of SWMU 10 Confirmatory Soil Sampling Metal Analytical Results, Arroyos, April–August 1997

Sample Attributes			Metals (EPA Methods 6010/6020/7000)[a] (mg/kg)								
Record Number[b]	ER Sample ID (Figure 3.4.4-3)	Sample Depth (ft)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
06158	CY10-SS-ARY-1	0.5–1.0	0.76 J (2.6)	73	0.61	0.16 J (0.17)	5.5	8.6	ND (0.043)	0.34 J (1.3)	ND (0.043)
06567	CY10-SS-ARY-2 (Off-site laboratory)	0.5–1.0	7.0	66.	0.72 J (0.99)	0.63 J (0.99)	**46.**[c]	13.	ND (0.10)	2.9	ND (0.40)
06567	CY10-SS-ARY-2-D (Off-site laboratory)	0.5–1.0	5.2	69.	**0.76 J (0.98)**	ND (0.39)	**27.**	9.8	ND (0.10)	2.0	ND (0.39)
06158	CY10-SS-ARY-3	0.5–1.0	0.93 J (2.5)	55	0.65	0.21	7.6	4.9	ND (0.042)	0.72 J (1.3)	0.07 J (0.17)
06158	CY10-SS-ARY-4	0.5–1.0	1.6 J (2.4)	59	0.7	0.3	**30**	12	ND (0.04)	0.83 J (1.2)	0.1 J (0.16)
06158	CY10-SS-ARY-5	0.5–1.0	0.9 J (2.7)	66 B	0.56 B	0.19 B	9.1	8.2	ND (0.045)	0.48 J (1.3)	ND (0.045)
06158	CY10-SS-ARY-6	0.5–1.0	0.82 J (2.3)	59 B	0.56 B	0.18 B	6.9	8.8	ND (0.038)	0.38 J (1.1)	ND (0.038)
06158	CY10-SS-ARY-7	0.5–1.0	ND (0.58)	30 B	0.3 B	0.11 J B (0.15)	4.4	5.5	ND (0.038)	0.36 J (1.2)	ND (0.038)
Quality Assurance/Quality Control Samples (all in µg/L)											
06158	CY10-RBF (EB)	NA	ND (3.4)	ND (3.9)	ND (0.11)	ND (0.22)	ND (8.4)	ND (1.7)	ND (0.22)	ND (1.7)	ND (0.22)
SNL/NM Canyons Soil Background 95th UTL or 95th Percentile Concentration[d]			9.8	246	0.75	0.64	18.8	18.9	0.055	3.0	<0.5

[a]EPA Method 6020 (EPA November 1986) used by on-site laboratory and EPA Methods 6010/7000 (EPA November 1986) used by off-site laboratory.
[b]Analysis request/chain of custody record.
[c]Values in bold exceed background soil concentrations.
[d]From Zamorski December 1997.

ARY = Arroyo.
B = Associated analyte was also observed in the method blank.
CY = Canyon.
D = Duplicate.
EB = Equipment blank.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
ft = Foot (feet).
ID = Identification.
J ( ) = The estimated value reported is either above the method detection limit (MDL) and less than the practical quantification limit (shown in parenthesis) for on-site laboratory analyses or above the instrument detection limit and less than the contract required detection limit (shown in parenthesis) for off-site laboratory analyses.
µg/L = Microgram(s) per liter.
mg/kg = Milligram(s) per kilogram.
NA = Not applicable.
ND ( ) = Not detected at or above the MDL, shown in parenthesis.
SNL/NM = Sandia National Laboratories, New Mexico.
SS = Surface soil sample.
SWMU = Solid waste management unit.
UTL = Upper tolerance limit.

Table 3.4.4-7
Summary of SWMU 10 Confirmatory Soil Sampling Gamma Spectroscopy Analysis, Arroyos, April–August 1997

Sample Attributes			Activity (pCi/g)							
			Uranium-238		Thorium-232		Uranium-235		Cesium-137	
Record Number[a]	ER Sample ID (Figure 3.4.4-3)	Sample Depth (ft)	Result	Error[b]	Result	Error[b]	Result	Error[b]	Result	Error[b]
06569	CY10-SS-ARY-1	0.5–1.0	9.43E-01	1.84E+00	**1.04E+00**[c]	5.02E-01	ND (2.17E-01)	--	1.22E-01	3.71E-02
06568	CY10-SS-ARY-2	0.5–1.0	ND (3.82E+00)	--	**1.62E+00**	7.51E-01	ND (2.81E-01)	--	1.30E-01	1.10E-01
06569	CY10-SS-ARY-3	0.5–1.0	ND (2.12E+00)	--	**1.61E+00**	7.48E-01	ND (2.98E-01)	--	5.77E-02	3.32E-02
06569	CY10-SS-ARY-4	0.5–1.0	**7.51E+00**	1.74E+00	**1.24E+00**	5.78E-01	ND (2.39E-01)	--	ND (4.13E-02)	--
06569	CY10-SS-ARY-5	0.5–1.0	ND (1.20E+00)	--	**1.06E+00**	5.00E-01	ND (2.16E-01)	--	1.12E-01	1.06E-01
06569	CY10-SS-ARY-6	0.5–1.0	ND (1.53E+00)	--	9.40E-01	4.49E-01	1.15E-01	8.04E-02	8.08E-02	2.62E-02
06569	CY10-SS-ARY-7	0.5–1.0	ND (1.44E+00)	--	8.56E-01	4.74E-01	ND (2.02E-01)	--	1.99E-02	1.33E-02
Background Soil Activity, Lower Canyons[d]			2.31	NA	1.03	NA	0.16	NA	1.55	NA
Quality Assurance/Quality Control Samples (all in pCi/mL)										
06569	CY10-RBF (EB)	NA	ND (8.86E-01)	--	ND (1.67E-01)	--	ND (1.42E-01)	--	ND (2.67E-02)	--

[a]Analysis request/chain of custody record.
[b]Two standard deviations about the mean detected activity.
[c]Values in bold exceed background soil activity.
[d]From Dinwiddie September 1997.

ARY = Arroyo
CY = Canyon.
EB = Equipment blank.
ER = Environmental Restoration.
ft = Foot (feet).
ID = Identification.
NA = Not applicable.
ND ( ) = Not detected at or above the minimum detectable activity, shown in parentheses.
pCi/g = Picocurie(s) per gram.
pCi/mL = Picocurie(s) per milliliter.
SNL/NM = Sandia National Laboratories, New Mexico.
SS = Surface soil sample.
SWMU = Solid waste management unit.
-- = Error not calculated for nondetectable results.

Explosives

During confirmatory sampling at SWMU 10, a total of seven soil samples and one duplicate sample were collected from the arroyo sediments and analyzed for HE. Results of the analyses indicate that no HE compounds were detected in the samples. Table 3.4.4-3 shows the detection limits used for HE analyses by both on- and off-site laboratories.

3.4.4.4.4 Quality Assurance/Quality Control Results

Data quality were assessed by reviewing the field QA/QC results and validating the laboratory QA/QC results for all analyses. This section summarizes the data quality assessment.

Metals

Table 3.4.4-1, Table 3.4.4-4, and Table 3.4.4-6 present results of the analysis of metals QA/QC samples collected during confirmatory sampling at SWMU 10. All QA/QC analyses were performed on site. QA/QC samples consisted of six equipment blanks (CY10-RBA, CY10-RBC, CY10-RBD, CY10-RBE, CY10-RBF, and CY10-RBG). Results of the analyses indicate that no metals were detected in the equipment blanks.

Eight duplicate samples (CY10-M3-S1-D, CY10-M4-S2-D, CY10-M6-T1-M-D, CY10-M9-T1-M-D, CY10-PIT-1D, CY10-M10-T1-B-D, CY10-SS-S3-D, and CY10-SS-ARY-2-D) were collected during confirmatory sampling at SWMU 10 and were analyzed on site for metals. Variability in the concentration levels of metals in certain duplicate samples and the equivalent primary samples was observed. Results for sample CY10-M3-S1-D indicated lower concentrations of barium, beryllium, cadmium, chromium, and lead than reported for the primary sample. However, similar variability resulted in the corresponding split samples for CY10-M3-S1 and CY10-M3-S1-D that were sent to the off-site laboratory. Results for samples CY10-M4-S2-D and CY10-M6-T1-M-D indicated significantly lower concentrations of chromium than reported for the primary samples. This variability was not reproduced in the split samples for CY10-M4-S2 and CY10-M4-S2-D, and CY10-M6-T1-M and CY10-M6-T1-D that were sent to the off-site laboratory. The concentration levels of metals in all other duplicate samples were comparable to those detected in the equivalent primary samples.

Twelve split samples (CY10-M2-T1-M, CY10-M4-S2, CY10-M4-S2-D, CY10-VM-1, CY10-M6-T1-M, CY10-M6-T1-M-D, CY10-M9-T1-M, CY10-M9-T1-M-D, CY10-PIT-1, CY10-PIT-1D, CY10-M10-T1-B, and CY10-M10-T1-B-D) were collected during confirmatory sampling at SWMU 10 and were verification analyzed off site for metals. Arsenic concentrations were substantially higher in all split samples. Chromium concentrations were also higher in several split samples, however, it is believed that this is caused by variations in the amount of vermiculite in the sample matrices (see Annex 3-A). Because of the higher MDL in the off-site analyses, metals such as cadmium, mercury, selenium, and silver were typically not detected in the off-site samples.

Relative percent differences (RPD) were calculated for metals detected in samples with an associated duplicate that were both analyzed by the same laboratory (Table 3.4.4-8). In general, the metals analyses had acceptable RPDs less than 25 percent. Arsenic RPDs were slightly above acceptable limits in two samples. Five of fourteen samples for barium and four of the fourteen samples for chromium exceeded the acceptable RPD. Three lead analyses exceeded 25 percent. However, the RPDs presented in Table 3.4.4-8 are typical of data for uncontaminated soil and are therefore acceptable.

Radionuclides

Tables 3.4.4-2, 3.4.4-5, and 3.4.4-7 present analytical results of radionuclides in QA/QC samples collected during confirmatory sampling at SWMU 10. All QA/QC analyses were performed on site. QA/QC samples consisted of six equipment blanks (CY10-RBA, CY10-RBC, CY10-RBD, CY10-RBE, CY10-RBF, and CY10-RBG). Results of the analyses indicate that no radionuclides were detected in the equipment blanks.

Four duplicate soil samples (CY10-M3-S1-D, CY10-M4-S2-D, CY10-M9-T1-M-D, and CY10-PIT-1-D) were collected during confirmatory sampling at SWMU 10 and were analyzed on site for radionuclides using gamma spectroscopy. Activities of radionuclides in the duplicate samples were comparable to those detected in the equivalent primary samples.

High Explosives

Results of the analysis of HE in the QA/QC samples that were collected during confirmatory sampling at SWMU 10 are not presented. However, six equipment blanks (CY10-RBA, CY10-RBC, CY10-RBD, CY10-RBE, CY10-RBF, and CY10-RBG) were included in the QA/QC samples. All QA/QC analyses were performed on site. Results of the analyses indicated that no HE were detected in the equipment blanks at MDLs ranging from 16 to 72 µg/L.

Eight duplicate samples (CY10-M3-S1-D, CY10-M4-S2-D, CY10-M6-T1-M-D, CY10-M9-T1-M-D, CY10-PIT-1D, CY10-M10-T1-B-D, CY10-SS-S3-D, and CY10-SS-ARY-2-D) were collected during post-VCM confirmatory sampling at SWMU 10 and were analyzed on site for HE. Results of the analyses indicate that no HE were detected in the sample duplicates.

Twelve split samples (CY10-M2-T1-M, CY10-M4-S2, CY10-M4-S2-D, CY10-VM-1, CY10-M6-T1-M, CY10-M6-T1-M-D, CY10-M9-T1-M, CY10-M9-T1-M-D, CY10-PIT-1, CY10-PIT-1D, CY10-M10-T1-B, and CY10-M10-T1-B-D) were collected during post-VCM confirmatory sampling at SWMU-10 and were verification analyzed off site for HE. Results of the analyses indicate that no HE were detected in the split samples.

Data Validation

SNL/NM Department 7713 Radiation Protection Sample Diagnostics (RPSD) reviewed all gamma spectroscopy results according to "Laboratory Data Review Guidelines,"

Table 3.4.4-8
Summary of SWMU 10 Field-Duplicate Relative Percent Differences

Sample Attributes		Relative Percent Differences								
Record Number[a]	ER Sample ID	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
Mound										
06157	CY10-M3-SI CY10-M3-SI-D (On-site laboratory)	NC[a]	46.7	NC[c]	73.0	40.0	52.5	NC[b]	NC[a]	NC[a]
06543	CY10-M4-S2 CY10-M4-S2-D (Off-site laboratory)	24.2	7.0	NC[a]	NC[b]	2.9	13.3	NC[b]	NC[b]	NC[b]
06157	CY10-M4-S2 CY10-M4-S2-D (On-site laboratory)	NC[a]	42.7	22.6	NC[a]	47.6	20.2	NC[b]	NC[a]	NC[a]
06566	CY10-M6-T1-M CY10-M6-T1-M-D (Off-site laboratory)	4.9	18.1	NC[a]	NC[b]	22.2	8.9	NC[b]	NC[b]	NC[b]
06008	CY10-M6-T1-M CY10-M6-T1-M-D (On-site laboratory)	3.6	0.0	NC[c]	NC[a]	8.0	1.5	NC[b]	NC[a]	NC[b]
06566	CY10-M9-T1-M CY10-M9-T1-M-D (Off-site laboratory)	5.1	0.0	NC[a]	NC[b]	10.8	15.4	NC[b]	NC[b]	NC[b]
06008	CY10-M9-T1-M CY10-M9-T1-M-D (On-site laboratory)	NC[a]	28.6	NC[c]	NC[c]	17.1	8.7	NC[b]	35.3	NC[b]
06542	CY10-PIT-1 CY10-PIT-1-D (Off-site laboratory)	1.2	0.0	8.0	NC[b]	8.0	5.1	NC[b]	NC[b]	NC[b]
06159	CY10-PIT-1 CY10-PIT-1-D (On-site laboratory)	0.0	4.3	8.7	8.0	15.4	0.0	NC[a]	6.7	6.8
06566	CY10-M10-T1-B CY10-M10-T1-B-D (Off-site laboratory)	10.5	20.3	NC[a]	NC[b]	24.0	10.2	NC[b]	NC[b]	NC[b]
06008	CY10-M10-T1-B CY10-M10-T1-B-D (On-site laboratory)	NC[a]	39.5	35.1	NC[a]	51.4	53.2	NC[b]	NC[a]	NC[b]

Refer to footnotes at end of table.

Table 3.4.4-8 (Concluded)
Summary of SWMU 10 Field-Duplicate Relative Percent Differences

Sample Attributes		Relative Percent Differences								
Record Number[a]	ER Sample ID	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
Grid										
06567	CY10-SS-S3 CY10-SS-S3-D (Off-site laboratory)	29.3	27.5	NC[a]	NC[b]	8.0	21.5	NC[b]	NC[b]	NC[b]
Arroyo										
06567	CY10-SS-ARY-2 CY10-SS-ARY-2-D (Off-site laboratory)	29.5	4.4	NC[a]	NC[b]	52.1	28.1	NC[b]	36.7	NC[b]
Former Vermiculite Mound										
600316	CY10-052698-GR-001-SS CY10-052698-GR-001-DU (Off-site laboratory) (Post-VCA)	1.9	7.3	17.8	27.0	8.6	9.9	NC[a]	13.7	NC[a]

[a]Analysis request/chain of custody record.

ARY = Arroyo
CY = Canyon.
D = Duplicate Analysis.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
ID = Identification.
M = Mound
NC[a] = Not calculated, both original sample and duplicate were estimated values.
NC[b] = Not calculated, at least one of the original sample or duplicate were nondetects.
NC[c] = Not calculated, associated analyte was also observed in the method blank.
SWMU = Solid waste management unit.

Procedure No. RPSD-02-11, Issue No. 2 (SNL/NM July 1996). In addition, all off-site laboratory results were reviewed and verified/validated according to "Data Verification/Validation Level 3—DV-3" in Attachment C of the Technical Operating Procedure 94-03, Rev. 0 (SNL/NM July 1994b). Annex 3-C summarizes off-site data validation results. The verification/validation process confirmed that the data are acceptable for use in this NFA proposal for SWMU 10.

3.4.5 Investigation #4 SNL/NM ER Project Voluntary Corrective Action (Solid Waste Removal) and Confirmatory Sampling

3.4.5.1 Nonsampling Data Collection

No nonsampling data collection activities were associated with the VCA and the confirmatory sampling activities.

3.4.5.2 Sampling Data Collection

A VCA was performed in May 1998 to remove the vermiculite mound from SWMU 10. Confirmatory sampling was conducted to confirm that no RCRA metals associated with vermiculite remained at the site at concentrations that might pose a level of risk under current and projected future land uses.

3.4.5.2.1 Voluntary Corrective Action Activities

A VCA (solid waste removal) was conducted in May 1998 to remove the vermiculite mound. Vermiculite, a naturally occurring mineral, has been shown to contain significant concentrations of chromium and barium (see Annex 3-A). Although toxicity characteristic leaching procedure analysis indicates that the chemical properties of vermiculite are such that the barium and chromium are not accessible to the environment (see Annex 3-A), it was determined that the material (60 cubic yards [yd^3]) should be removed from the site. The material excavated (Figure 3.4.5-1) was subsequently disposed of as RCRA Subtitle D solid waste using standard SNL/NM-approved waste disposal protocols.

3.4.5.2.2 Confirmatory Sampling

On May 26, 1998, two soil samples (CY10-052698-GR-001 and CY10-052698-GR-002) were collected from beneath the former vermiculite mound location. In addition, one duplicate soil sample was collected (CY10-052698-GR-001-DU). Figure 3.4.5-1 shows sample locations. SNL/NM followed AR/COC and sample documentation procedures for all samples collected. The samples were analyzed for RCRA metals plus beryllium using EPA Method 6010A (EPA November 1986). Mercury was analyzed using EPA Method 7471 (EPA November 1986). All analyses were performed by General Engineering Laboratories in Charleston, South Carolina. The laboratory results were reviewed and verified/validated according to "Data Verification/Validation Level 3—DV3 in Attachment C of the Technical Operating Procedure 94-03, Rev. 0 (SNL/NM July 1994b). All confirmatory sampling data are acceptable for use in this NFA proposal for SWMU 10.

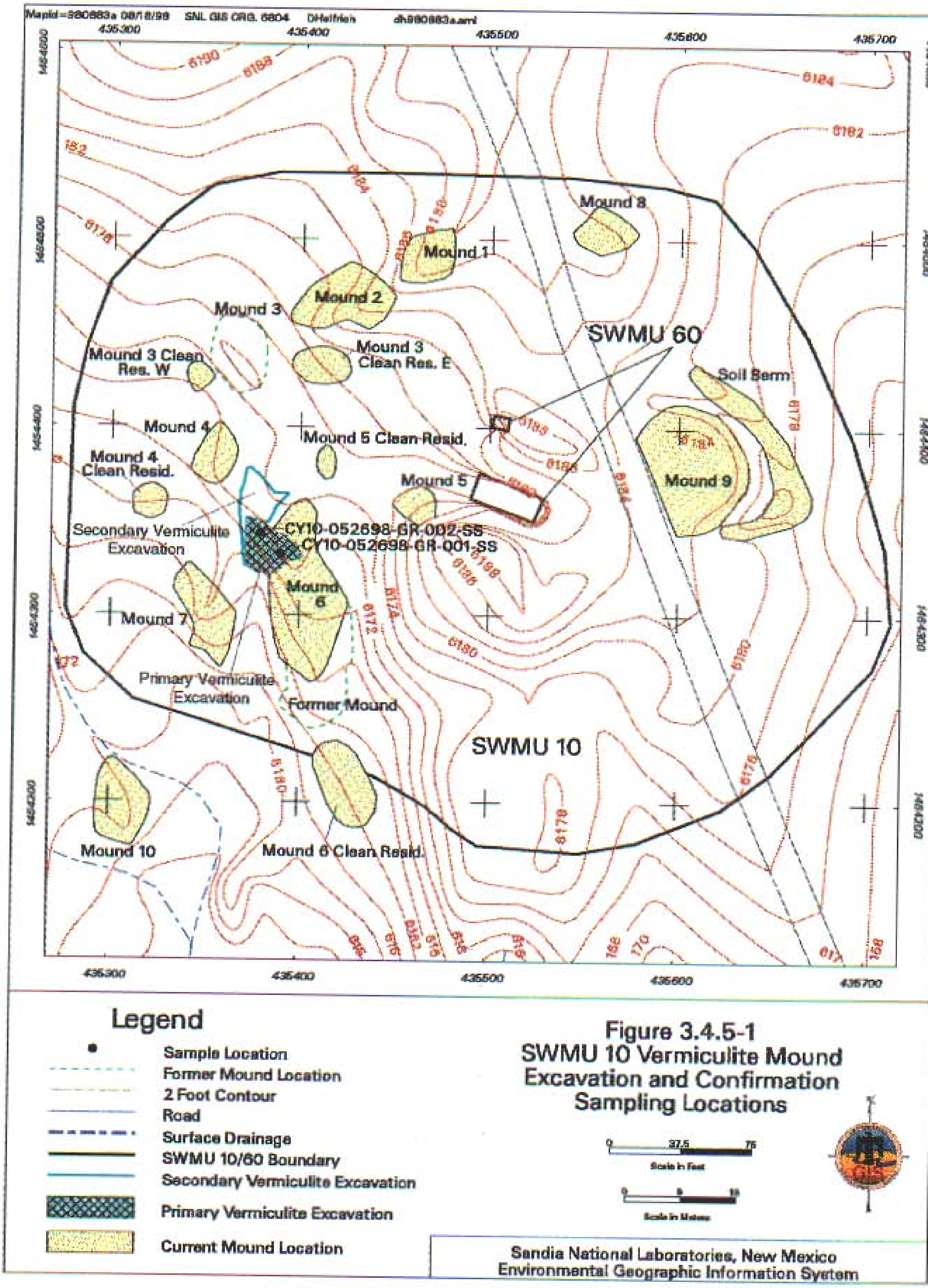

Figure 3.4.5-1
SWMU 10 Vermiculite Mound Excavation and Confirmation Sampling Locations

3.4.5.3 Data Gaps

There are no data gaps related to characterization of SWMU 10.

3.4.5.4 Results and Conclusions

All metals concentrations in the confirmatory soil samples were below the background limits (Table 3.4.4–1). The removal of 60 yd^3 of vermiculite and vermiculite/soil mixture successfully eliminated the primary source of vermiculite from SWMU 10.

3.5 Site Conceptual Model

This section describes the conceptual model for SWMU 10 and summarizes the nature and extent of contamination and the environmental fate of COCs.

3.5.1 Nature and Extent of Contamination

The COCs at SWMU 10 are metals and radionuclides associated primarily with accidental detonation of two mock weapons. Other tests conducted at the site may have contributed to contamination at SWMU 10 also, but the specific materials involved with those tests are unknown. Table 3.5.1-1 summarizes the COCs for SWMU 10.

Fifty-three environmental samples were collected from the soil/debris mounds. In addition, 17 environmental samples were collected from the fragmentation area (radial grid pattern), and seven environmental samples were collected from the arroyos. Whether any metal or radiological COC exceeded the background concentration limit in any sample was the determining factor in designating potential contaminants. In the case of nondetectable results, the MDL (for metals) or MDA (for radionuclides) was compared to the background concentration limit. As a result, metal COCs included barium, beryllium, cadmium, chromium, lead, mercury, selenium, and silver. Based on an extensive investigation into the chemical composition of natural vermiculite (see Annex 3-A), it is believed that significantly elevated barium and chromium concentrations are attributable to vermiculite present at the site prior to conducting the VCA. Therefore, no pre-VCA samples from the former vermiculite mound or vicinity were included to define the nature and extent of contamination. Radiological COCs included uranium-238, uranium-235, and thorium-232. Table 3.5.1-1 lists the COCs and the sample locations where the COCs exceed the maximum background concentration limits.

Metal COCs that exceed background limits typically occur as isolated *hot spots* of one or two different COCs with no particular COC associations or as areas that could be delineated as contaminated. However, sample location CY10-PIT-1 (the surface water accumulation area, see Section 3.4.4.2.2) did contain several metal COCs slightly above background concentration limits. Radionuclide COCs associated with DU (uranium-238) were detected above background limits where VCM activities were conducted at Mounds 3 and 6. All other occurrences of radionuclide COCs above background concentration limits were sporadic. It is expected that no metal or radionuclide COCs are bgs at any location within SWMU 10, because the release

Table 3.5.1-1
Summary of COCs for SWMU 10

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/Canyons[a] (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration[b] (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded[c]
Inorganic nonradiological	76 environmental, 6 duplicates, 7 splits	Ba	246	250	109	CY10-PIT-1 (split) CY10-PIT-1D (duplicate)
		Be	0.75	3.4 B	0.70	CY10-M3-S1 CY10-M3-S2 CY10-M6-T3-M CY10-M6-S2 CY10-M8-T1-B CY10-M9-T1-M CY10-M9-T2-B CY10-M9-T3-M CY10-PIT-1 (plus duplicate & split) CY10-M10-T3-M CY10-SS-N2 CY10-SS-N3 CY10-SS-NE1 CY10-SS-SE3 CY10-SS-S3 CY10-SS-S4 CY10-SS-SW4 CY10-SS-NW4 CY10-SS-ARY-2-D
		Cd	0.64	0.65	0.25	CY10-PIT-1D
		Cr	18.8	46	12.0	CY10-M1-T2-M CY10-M1-T2-B CY10-M2-T1-M CY10-M2-T1-M (split) CY10-M3-S2 CY10-M5-S1 CY10-M6-T2-M CY10-M7-T2-B CY10-SS-ARY-2 CY10-SS-ARY-2-D CY10-SS-ARY-4
		Pb	18.9	30	8.3	CY10-PIT-1 (plus duplicate & splits) CY10-SS-E4

Refer to footnotes at end of table.

Table 3.5.1-1 (Continued)
Summary of COCs for SWMU 10

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/Canyons[a] (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration[b] (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded[c]
		Hg	0.055	ND (0.075 J)	0.059	CY10-M1-T2-B CY10-M2-T1-M (plus split) CY10-M6-T1-M CY10-M6-T1-M-D CY10-M9-T1-M CY10-M9-T1-M-D CY-M10-T1-B CY10-M10-T1-B-D CY10-PIT-1 (plus duplicate and splits) All off-site analyses[d]
		Se	3.0	3.1	1.1	CY10-PIT1D
		Ag	<0.5	0.61	0.11	CY10-PIT-1 CY10-PIT-1D
Radiological	70 environmental, 3 duplicates	U-238	2.31 pCi/g	8.41 pCi/g	Not calculated[e]	CY10-M1-T1-M CY10-M3-S1 CY10-M3-S1-D CY10-M3-S2 CY10-M3-S3 CY10-M5-S2 CY10-M6-S2 CY10-M9-T2-U CY10-SS-ARY-4 Mound Samples[f] Arroyo Sample[g]
		Th-232	1.03 pCi/g	2.29 pCi/g	Not calculated	CY10-M1-T1-M CY10-M1-T1-B CY10-M1-T2-M CY10-M1-T2-B CY10-M2-T1-M CY10-M2-T1-B CY10-M2-T2-M CY10-M2-T2-B CY10-M2-T3-M CY10-M3-S1 CY10-M3-S1-D CY10-M5-S1 CY10-M6-T3-M CY10-M6-S1 CY10-M7-T1-M CY10-M7-T1-B CY10-M7-T2-M CY10-M7-T3-M CY10-M7-T3-B CY10-M7-T3-M CY10-M8-T1-B CY10-M9-T1-M-D CY10-M9-T1-M CY10-M9-T1-B CY10-M9-T2-U CY10-M9-T3-M CY10-PIT-1 CY10-PIT-1-D CY10-SB9-2 CY10-M10-T1-B CY10-M10-T2-M Grid Samples[h] Arroyo Samples[i]

Refer to footnotes at end of table.

Table 3.5.1-1 (Concluded)
Summary of COCs for SWMU 10

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/Canyons[a] (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration[b] (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded[c]
		U-235	0.16	0.303 pCi/g	Not calculated	CY10-M1-T1-B CY10-M2-T1-M CY10-M3-S1 CY10-M3-S2 CY10-M3-S3 CY10-M6-T3-M CY10-M9-T2-B CY10-PIT-1-D Grid Samples[j] Arroyo Samples[k] Mound Samples[l]

[a]From SNL/NM December 1997 (metals) and Dinwiddie September 1997 (radionuclides).
[b]Average concentration includes all samples, duplicates, and splits. For nondetectable results, the detection limit is used to calculate the average.
[c]For radionuclide COCs, sampling locations are only reported where detected activities exceed background. Nondetectable activities, where the minimum detectable activity exceeds background, are not listed.
[d]The detection limits used in the off-site analyses for mercury were above the background concentration limit.
[e]An average minimum detectable activity is not calculated due to the variability in instrument counting error and the number of reported nondetectable activities.
[f]Eleven mean detected activities for nondetect results from mound samples exceeded the maximum background limit.
[g]One mean detected activity for nondetect results from arroyo samples exceeded the maximum background limit.
[h]All grid samples exceed background for thorium-232 except CY10-SS-NE1, NE3, E4, SE1, and NW1.
[i]All Arroyo samples exceeded background for thorium-232 except CY10-SS-ARY-6 and 7.
[j]Sixteen mean detected activities for nondetect results from grid samples exceeded the maximum background limit.
[k]Six mean detected activities for nondetect results from arroyo samples exceeded the maximum background limit.
[l]Thirty-two mean detected activities for nondetect results from mound samples exceeded the maximum background limit.

B = Associate analyte was also observed in the method blank.
COC = Constituent of concern.
ND ( ) = Not detected at or above the method detection limit or the minimum detectable activity, shown in parenthesis.
mg/kg = Milligram(s) per gram.
pCi/g = Picocurie(s) per gram.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid waste management unit.

mechanism at the site was primarily caused by dispersion from explosives and salvage operations that produced aboveground soil/debris mounds.

3.5.2 Environmental Fate

Primary sources of COCs for SWMU 10 were DU, HE, and metals associated with accidental detonation of two mock weapons (Figure 3.5.2-1). Other tests conducted at the site may have contributed to contamination at SWMU 10 also, but specific details regarding those tests are unknown. It is believed that the soil/debris mounds were formed as the result of grading operations for site access, from construction of the SWMU 60 bunker, and from salvage operations conducted after the detonation of the mock weapons. Analytical results indicated that no residual HE compounds are present in the soil/debris mounds or surrounding surface soils (see Section 3.4.4.3). A radiological VCM was conducted in 1996 to remove radiological anomalies associated with the soil/debris mounds. A VCA was conducted in 1998 to remove the vermiculite mound.

Table 3.5.1-1 lists potential COCs for SWMU 10. Based upon the nature and extent of contamination at the site (Section 3.5.1), metal COCs occur sporadically around the site at concentrations higher than the maximum background concentrations. Radionuclide COCs occur in the residual mounds at concentrations higher than the maximum background activities at several locations where remediation was conducted (specifically Mound 3 and 6). Sample location CY10-PIT-1 has been shown to contain both metal and radionuclide COCs consistently above background concentration limits. Excluding those areas specifically mentioned above, the majority of the potential COCs are present in concentrations just slightly exceeding the maximum background limits. All potential COCs were retained in the conceptual model and evaluated in the human health and ecological risk assessments.

Since radiation anomalies were removed from the site, the secondary source of COCs is residual metals and radionuclides in the soil/debris mounds and surface soil. No historical testing activities have been conducted at SWMU 10 that resulted in the presence of COCs below the surface soil. The secondary release mechanisms at SWMU 10 are, therefore, limited to suspension and/or dissolution of COCs in surface-water runoff and percolation to the vadose zone, direct contact with soil (radionuclides only), dust emissions, and uptake of COCs in the soil by biota (Figure 3.5.2-1). The depth to groundwater at the site (at approximately 180 feet bgs) precludes migration of COCs to the aquifer. The pathways to receptors are surface water, soil water, air, and soil (radionuclides). Biota are also a pathway through food chain transfers. Annex 3-D provides additional discussion of the fate and transport of COCs at SWMU 10.

The current and future land use for SWMU 10 is industrial (DOE and USAF March 1996). However, because the site is close to private housing developments, a residential land use is also considered. For all applicable pathways, the exposure route for the receptor is dermal contact and ingestion/inhalation. In addition, the receptor could be exposed by external irradiation from radionuclides in soil. Only external irradiation and ingestion of soil are considered major exposure routes for the receptor. Potential biota receptors include flora and fauna at the site. Similar to the human receptor, external irradiation and ingestion of soil are considered major exposure routes for biota, in addition to ingesting COCs through food chain transfers or indirect uptake. Annex 3-D provides additional discussion of the exposure routes and receptors at SWMU 10.

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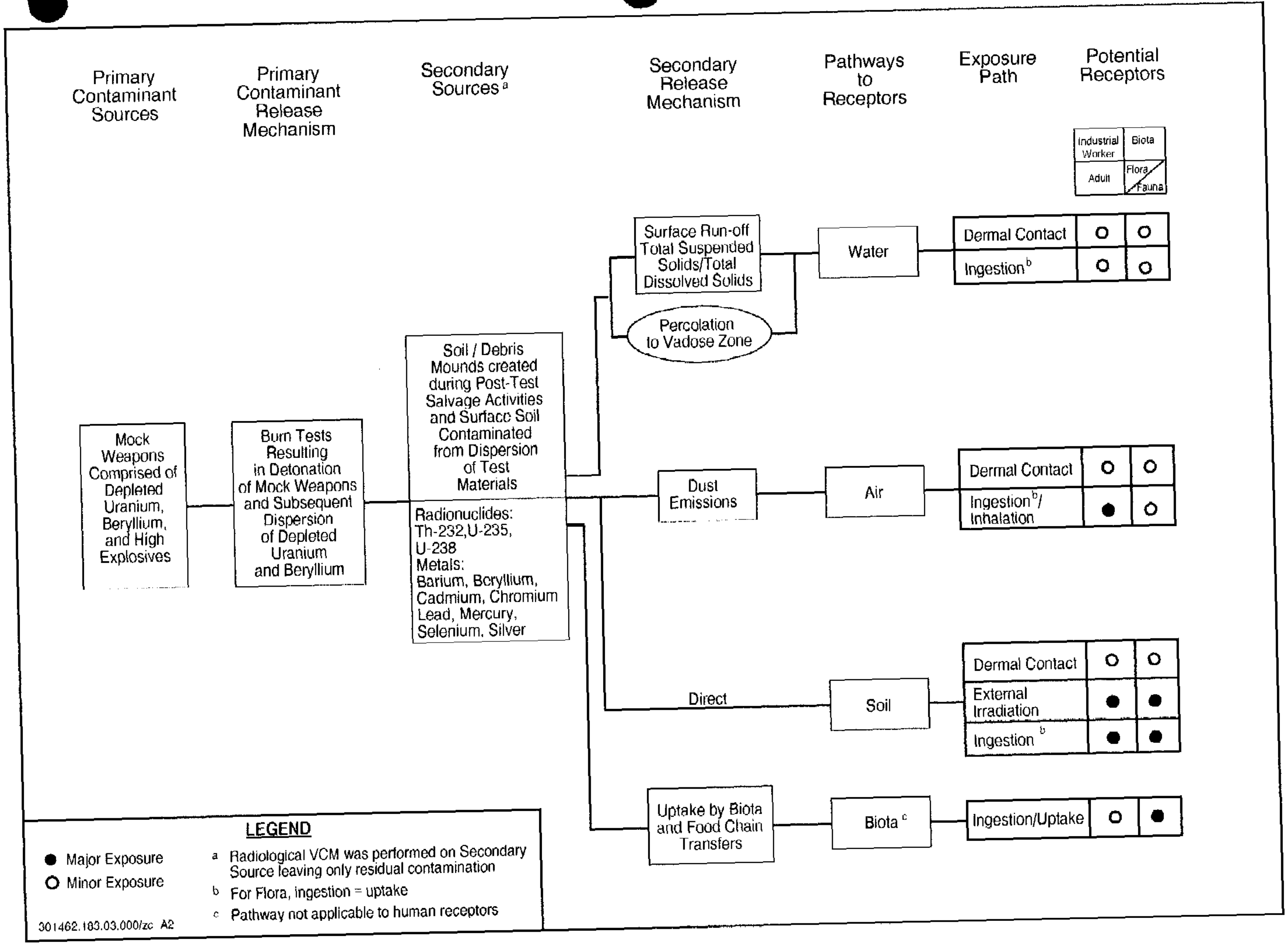

Figure 3.5.2-1

Conceptual Model Flow Diagram for SWMU 10, Burial Mounds

3.6 Site Assessments

The site assessment process for SWMU 10 includes risk screening assessments and risk baseline assessments for both human health risk and ecological risk. This section briefly summarizes the site assessment results. Annex 3-D provides details of the site assessment.

3.6.1 Summary

The site assessment concludes that SWMU 10 does not have potential to affect human health under an industrial land-use scenario. After consideration of the uncertainties of related available data and modeling assumptions, ecological risks associated with SWMU 10 were found to be very low. Section 3.6.2 briefly describes and Annex 3-D provides detailed descriptions of the site assessments.

3.6.2 Screening Assessments

Risk screening assessments were performed for both human health risk and ecological risk for SWMU 10. The following discusses the results.

3.6.2.1 Human Health

SWMU 10 has been recommended for industrial land use; however, based upon recommendations from the Citizen's Advisory Board, a residential land use is also considered (DOE and USAF March 1996). Annex 3-D provides a complete discussion of the risk assessment process, results, and uncertainties. Because COCs are present in concentrations or activities greater than background levels, it was necessary to perform a health risk assessment analysis for the site. Besides COC metals, this assessment included any volatile organic compounds or semivolatile organic compounds detected above their reporting limits and any radionuclide compounds either detected above background levels and/or MDAs. The risk assessment process provides a quantitative evaluation of the potential adverse human health effects caused by constituents in the site's soil. The Risk Assessment Report calculated the hazard index (HI) and excess cancer risk for both an industrial land-use and residential land-use setting. The excess cancer risk from nonradiological COCs and the radiological COCs is not additive (EPA 1989).

The HI calculated for SWMU 10 nonradiological COCs is 0.01 for an industrial land-use setting, which is less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. Since the background HI is 0.0 the incremental HI is also 0.01. The total excess cancer risk for SWMU 10 nonradiological COCs is 1E-7 for an industrial land-use setting. Guidance from the NMED indicates that excess lifetime risk of developing cancer by an individual must be less than 1E-6 for Class A and B carcinogens and less than 1E-5 for Class C carcinogens (NMED March 1998). The total excess cancer risk is driven by chromium, total. Chromium, total, is assumed to be chromium VI (most conservative) which is a Class A carcinogen. Thus, the excess cancer risk for this site is below the suggested acceptable risk value of 1E-6. The incremental excess cancer risk for SWMU 10 is 1E-7.

The incremental total effective dose equivalent (TEDE) for radionuclides for an industrial land-use setting for SWMU 10 is 3.8 millirems per year (mrem/yr), which is well below the recommended dose limit of 15 mrem/yr found in EPA's OSWER Directive No. 9200.4-18 and reflected in a document entitled "Sandia National Laboratories/New Mexico Environmental Restoration Project—RESRAD Input Parameter Assumptions and Justification" (February 1998). The incremental excess cancer risk for radionuclides is 5.5E-5 for an industrial land-use scenario, which is much less than risk values calculated from naturally occurring radiation and from intakes considered background concentration values.

The HI calculated for SWMU 10 nonradiological COCs is 2 for a residential land-use setting, which is above the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). Incremental risk is determined by subtracting risk associated with background from potential nonradiological COC risk. The incremental HI is 0.15. The excess cancer risk for SWMU 10 nonradiological COCs is 2E-7 for a residential land-use setting. Guidance from the NMED indicates that excess lifetime risk of developing cancer by an individual must be less than 1E-6 for Class A and B carcinogens and less than 1E-5 for Class C carcinogens (NMED March 1998). Thus, the excess cancer risk for this site is below the suggested acceptable risk value of 1E-6. The incremental excess cancer risk for SWMU 10 is 2E-7.

The incremental TEDE for radionuclides for a residential with loss of institutional control, land-use setting for SWMU 10 is 6.8 mrem/yr, which is well below the recommended dose limit of 75 mrem/yr found in "Sandia National Laboratories/New Mexico Environmental Restoration Project—RESRAD Input Parameter Assumptions and Justification" (February 1998). The incremental excess cancer risk for radionuclides is 1.1E-4 for a residential land-use scenario, which is much less than risk values calculated from naturally occurring radiation and from intakes considered background concentration values. The report concludes that SWMU 10 does not have potential to affect human health under either an industrial or a residential land-use scenario.

3.6.2.2 Ecological

An ecological screening assessment that corresponds with the screening procedures in the EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997) was performed as set forth by the NMED Risk-Based Decision Tree (NMED March 1998). An early step in the evaluation is to compare COC concentration levels and to identify potentially bioaccumulative constituents. This is presented in Annex 3-D, Sections III and VI and Sections VII.2 and VII.3. This methodology requires developing a site conceptual model and food web model as well as selecting ecological receptors. Each of these items is presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER Program, Sandia National Laboratories/New Mexico" (IT July 1998) and will not be duplicated here. The screen also includes the estimation of exposure and ecological risk.

Tables 14, 15, 16, and 17 of Annex 3-D present the results of the ecological risk assessment screen. Site-specific information was incorporated into the screening assessment when such data were available. Hazard quotients greater than unity were originally predicted; however, closer examination of the exposure assumptions revealed an overestimation of risk primarily attributed to exposure concentration (maximum COC concentration was used in the estimation of risk) and exposure setting (area use factors of one were assumed), background risk, quality of analytical data, and the use of detection limits as exposure concentrations. Based upon evaluation of these uncertainties, ecological risks associated with this site are expected to be very low.

3.6.3 Baseline Risk Assessments

This section discusses the baseline risk assessments for human health risk and ecological risk.

3.6.3.1 Human Health

Based upon the fact that human health results of the screening assessment summarized in Section 3.6.2.1 indicate that SWMU 10 does not have potential to affect human health under an industrial or residential land-use scenario, a baseline human health risk assessment is not required for SWMU 10.

3.6.3.2 Ecological

Based upon the screening assessment summarized in Section 3.6.2.2, a baseline ecological risk assessment is not required for SWMU 10.

3.6.4 Other Applicable Assessments

No other applicable assessments have been performed at SWMU 10.

3.7 No Further Action Proposal

SWMU 10 is proposed for an NFA decision based upon all the supporting information in this chapter. The rationale and criterion for the NFA proposal is provided below.

3.7.1 Rationale

Based upon field investigation data and the human health risk assessment analysis, an NFA is being recommended for SWMU 10 for the following reason: No COCs (metals and radionuclides) were present in concentrations considered hazardous to human health for an industrial or a residential land-use scenario.

3.7.2 Criterion

Based upon the evidence provided above, SWMU 10 is proposed for an NFA decision in conformance with Criterion 5 (NMED March 1998), which states that "The SWMU/AOC has been characterized or remedied in accordance with current applicable state or federal regulations and that available data indicate that contaminants pose an acceptable level of risk under current and projected future land use."

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ANNEX 3-D
Risk Screening Assessment

TABLE OF CONTENTS

LIST OF TABLES

SWMU 10: RISK SCREENING ASSESSMENT REPORT

I. Site Description and History

Solid Waste Management Unit (SWMU) 10 is associated with SWMU 60 and is located near the northeastern corner of Kirtland Air Force Base (KAFB), on federally owned land controlled by KAFB (SNL/NM July 1994a). Access to the general area is by way of Coyote Springs Road to Pendulum Road and then continue approximately 1.5 miles north (Gaither Date [Unk]; Oldewage May 1993). The site lies on approximately 2.9 acres at a mean elevation of 6,175 feet above sea level (SNL/NM April 1995).

SWMU 10, Burial Mounds, inactive since the late 1970s, consists of nine soil/debris mounds, one former soil/debris mound removed in April 1996, and a former vermiculite mound removed in May 1998. The former soil/debris mound was removed in conjunction with a radiological Voluntary Corrective Measure (VCM) (Section 3.4.4). The former vermiculite mound was removed as solid waste in a Voluntary Corrective Action (VCA) (Section 3.4.5). The site boundary is based upon the fragmentation radius of depleted uranium (DU) fragments found in the initial surface gamma radiation survey conducted in October 1993 (RUST Geotech Inc. December 1994).

SWMU 10 lies on Tesajo-Millett stony sandy loams that are underlain by igneous and metamorphic Precambrian rocks (USDA June 1977). Immediate topographic relief around the site is approximately 50 feet. The nearest monitoring wells, the Greystone Manor and TSA-1 wells, are located approximately 2.2 miles southwest and southeast of SWMU 10, respectively. Groundwater conditions at TSA-1 are probably more representative of conditions at SWMU 10, because SWMU 10 and TSA-1 are east of the Coyote Fault on thin alluvium deposits surrounded by Precambrian rocks (IT May 1994). At TSA-1 well, semiconfined to confined groundwater is encountered in fractured Precambrian bedrock at a depth of 180 feet below ground surface (bgs) (IT May 1994). Local groundwater flow in the vicinity of SWMU 10 may be complicated because of abundant fractures and faults in the area.

For a detailed discussion of the local setting and other information pertaining to SWMU 10, refer to the "RCRA [Resource Conservation and Recovery Act] Facility Investigation Work Plan for OU 1333, Canyons Test Area" (SNL/NM September 1995).

II. Comparison of Results to Data Quality Objectives

The confirmatory sampling conducted at SWMU 10 was designed to collect samples adequate to:

- Determine whether hazardous waste or hazardous constituents have been released at the site
- Characterize the nature and extent of any releases

- Verify that radiation anomalies have been removed
- Provide sufficient Level 3 analytical data to support risk screening assessments.

Table 1 summarizes the sample location design for SWMU 10. The source of potential contaminants of concern (COC) at SWMU 10 is high explosives (HE), DU, and metals used in a failed Torch-Activated Burn System (TABS) test conducted on two mock nuclear weapons. Other experiments conducted prior to the TABS test may also have contributed COCs at SWMU 10, but the specific materials used in those tests are unknown. Based upon salvage activities performed immediately after the failed TABS test, the radiological VCM conducted in 1996, and the VCA removal of the vermiculite mound in 1998, only residual COCs remain at the site.

The number and location of the samples collected depended upon the completeness of historical information, results of previous radiological surveys performed at the site, and activities conducted during the VCM. In addition, samples were collected from areas where contamination could potentially migrate as a result of surface-water runoff, such as the nearby arroyos and topographically low areas (e.g., the pit near Mound 9).

Table 2 identifies the analytical methods and data quality requirements necessary to (1) characterize adequately hazardous waste or hazardous constituents associated with the HE, DU, and metals used in TABS test conducted at the site; and (2) support risk screening assessments.

A total of 76 locations were sampled at SWMU 10 and analyzed by Sandia National Laboratories/New Mexico (SNL/NM) on-site laboratories. Twenty percent of the samples were sent off site for verification analyses for both RCRA metals plus beryllium and HE. The method detection limits (MDL) for both on-and off-site analyses were below the quantified background concentration limits for RCRA metals plus beryllium, with only one exception. The MDL used by the off-site laboratory for analysis of some samples for mercury exceeded the 0.055 milligrams per kilogram (mg/kg) background concentration limit. Silver does not have a quantified background concentration, thus comparison of the MDL to a background concentration could not be made.

All gamma spectroscopy data were reviewed by SNL/NM Department 7713 (Radiation Protection Sample Diagnostic Laboratory) according to "Laboratory Data Review Guidelines," Procedure No. RPSD-02-11, Issue No: 02 (SNL/NM July 1996). In addition, all off-site laboratory results were reviewed and verified/validated according to "Data Verification/Validation Level 3—DV-3" in Attachment C of the Technical Operating Procedure 94-03, Rev. 0 (SNL/NM July 1994). The reviews confirmed that the data are acceptable for use in the no further action (NFA) proposal for SWMU 10. The data quality objectives for SWMU 10 have been met.

Table 1
Summary of Sampling Performed to Meet Data Quality Objectives

SWMU 10 Secondary Source Areas	Potential COC	Number of Sampling Locations	Sample Density	Sampling Location Rationale
Soil/debris Mounds	Residual HE, DU, and metals	50	Judgmental based upon Mound 1: 4 samples Mound 2: 6 samples Mound 3: 4 samples Mound 4: 2 samples Mound 5: 2 samples Mound 6: 8 samples Mound 7: 6 samples Mound 8: 2 samples Mound 9: 6 samples Mound 10: 6 samples Soil Berm: 2 samples Pit : 1 sample Vermiculite Mound: 1 sample (Pre-VCA)	Samples collected from middle and bottom of trenches excavated during VCM (Mounds 1, 2, 6, 7, 8, and 10). Samples collected at surface (0 to 12 inches) where mounds completely removed during VCM (e.g., Mounds 3, 4, 5, and part of 6). Samples collected from middle and bottom of three trenches excavated through Mound 9 (not investigated during VCM). Surface samples collected from soil berm and pit near Mound 9, and vermiculite mound.
		2	Vermiculite Mound: 2 samples (Post-VCA)	Confirmation samples collected beneath former vermiculite mound location.
Fragmentation Area (surface soil)	Residual HE, DU, and metals	17	Random based upon eight cardinal direction-based spokes centered on SWMU 60 bunker and concentric circles at distances of 25, 50, 100, and 200 feet	Sample locations distributed on the basis of expected radial distribution from original explosion during failed TABS test. Samples added to grid where mound sample coverage did not exist, and samples eliminated where mound sample coverage overlapped grid.
Arroyo (sediments)	Residual HE, DU, and metals	7	Judgmental based upon 150-foot intervals starting 250 feet upstream from SWMU 10 to 250 feet downstream from SWMU 10.	Sample locations distributed upstream and downstream to investigate possible COC migration from SWMU 10.

COC = Constituents of concern.
DU = Depleted uranium.
HE = High explosive.
SWMU = Solid waste management unit.
TABS = Torch-Activated Burn System.
VCA = Voluntary Corrective Action
VCM = Voluntary Corrective Measure.

Table 2
Summary of Data Quality Requirements

Analytical Requirement	Data Quality Level	ER Chemistry Laboratory Department 6133 SNL/NM	Radiation Protection Sample Diagnostics Laboratory Department 7713 SNL/NM	Lockheed Analytical Services Las Vegas, Nevada	General Engineering Laboratories, Charleston, South Carolina
RCRA metals plus beryllium EPA Method 6010/7000[a]	Level 3	72 samples 6 samples (internal duplicates)	Not applicable	2 samples 7 samples (off-site duplicates) 7 samples (off-site internal duplicates)	2 samples 1 sample (off-site internal duplicate)
HE compounds EPA Method 8330[a]	Level 3	72 samples 6 samples (internal duplicates)	Not applicable	2 samples 7 samples (off-site duplicates) 7 samples (off-site internal duplicates)	Not applicable
Gamma Spectroscopy	Level 2	Not applicable	50 samples 4 samples (internal duplicates)	Not applicable	Not applicable

[a]EPA November 1986.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
HE = High explosive.
RCRA = Resource Conservation and Recovery Act.
SNL/NM = Sandia National Laboratories/New Mexico.

III. Determination of Nature, Rate, and Extent of Contamination

III.1 Introduction

Determining the nature, rate, and extent of contamination at SWMU 10 was based upon an initial conceptual model validated by confirmatory sampling at the site. The initial conceptual model was developed from historical background information including site inspections, interviews, historical photographs, and radiological surveys. The data quality objectives in the Sampling and Analysis Plan (SNL/NM March 1997) and Bullets of Understanding relating to the sampling (NMED DOE OB April 1997), identified the sample locations, sample density, sample depth, and analytical requirements. The sample data were used subsequently to develop the final conceptual model for SWMU 10, which is presented in Section 3.5 of the associated NFA proposal. The quality of the data specifically used to determine the nature, rate, and extent of contamination are described below.

III.2 Nature of Contamination

The nature of contamination at SWMU 10 was determined with analytical testing of soil media and the potential of relevant COCs to degrade (Section V). The analytical requirements included RCRA metals plus beryllium to characterize nonradiological inorganic constituents released at the site. Gamma spectroscopy was used to characterize residual DU concentrations remaining after the VCM activities were conducted at the site. HE analyses were performed to characterize any potential explosive materials that may have not been consumed during the failed TABS test. These analytes and methods are appropriate to characterize the COCs and potential degradation products associated with the historical activities at SWMU 10.

III.3 Rate of Contaminant Migration

SWMU 10 is an inactive site, and therefore, all primary sources of COCs (test activities involving hazardous and radioactive materials) have been removed. In addition, post-test salvage operations and VCM and VCA activities conducted in 1996 and 1998, respectively, have reduced contamination at SWMU 10 to residual levels. As a result, only secondary sources of COCs in soil remain at the site. The rate of COC migration depends primarily upon site meteorological and surface hydrologic processes as described in Section V. Data available from the Site-Wide Hydrogeologic Characterization Project (published annually); numerous SNL/NM air, surface water, and radiological monitoring programs; biological surveys; and other governmental atmospheric monitoring at the KAFB (i.e., National Oceanographic and Atmospheric Administration) are adequate to characterize the rate of COC migration at SWMU 10.

III.4 Extent of Contamination

Soil samples were collected from the existing and former soil/debris mound locations and from surface soils within the fragmentation radius surrounding the SWMU 60 bunker where two mock weapons were detonated during the failed TABS test. In addition, samples were collected from the soil berm adjacent to Mound 9 and from areas where contamination could potentially migrate as a result of surface-water runoff, including nearby arroyos and topographically low areas (e.g., the pit near Mound 9). These sample locations are deemed appropriate to determine the lateral extent of COC migration.

The sample density for soil/debris mounds was based upon the size of the mounds and the number of trenches excavated through the mounds during VCM activities. The sample density for surface soil was based upon the expected radial distribution of materials resulting from the original explosion at the SWMU 60 bunker and the expected uniformity of COCs at specific radii from the bunker. The sample density for the arroyos was based upon the extent of potential migration from surface water runoff in the vicinity of the site. The number of samples was deemed sufficient to establish the presence of residual COCs at the site or in potential migration pathways near the site.

Because of the relatively low solubility of most metals and organic compounds, limited precipitation, and high evapotranspiration, the vertical rate of contamination migration is expected to be extremely low. Because the soil/debris mounds were constructed above grade, samples were collected from the middle of the trenches approximately 1-foot below ground surface (bgs) and from the bottom of the trenches approximately 2 to 3 feet bgs. Samples from the bottoms of the trenches were collected approximately 0.5 feet below the actual trench bottom to ensure undisturbed material was collected from below grade. Surface soil and arroyo sediment samples were collected within 0 to 12 inches of the ground surface, including samples collected from mounds that were removed completely during the VCM. There is no historical information to indicate that any subsurface disturbance, testing, or disposal ever occurred at the site that could mix surface soils beneath the 12-inch depth, with the exception of the former vermiculite mound, which was excavated and removed from the site. Therefore, the sample collection protocol used at SWMU 10 is representative of the media potentially impacted by site activities and is sufficient to determine the vertical extent of COC migration.

In summary, the design of the confirmatory sampling was appropriate and adequate to determine the nature, rate, and extent of contamination.

IV. Comparison of COCs to Background Screening Levels

Site history and characterization activities are used to identify potential COCs. The identification of COCs and the sampling to determine the concentration levels of those COCs across the site are described in the SWMU 10 NFA proposal. Generally, COCs evaluated in this risk assessment include all detected organics and radiological contaminants and all inorganic COCs that were analyzed for. If the detection limit of an organic compound was too high (could possibly cause an adverse effect to human health or the environment), the compound was retained. Nondetect organics that were not included in this assessment were determined to have sufficiently low detection limits to ensure protection of human health and the environment. In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentration value of each COC determined for the entire site. The SNL/NM maximum background concentration (Dinwiddie September 1997; Zamorski December 1997) was selected to provide the background screen in Tables 3 and 4. Human health nonradiological COCs were also compared to SNL/NM proposed Subpart S action levels (Table 1) (IT July 1994).

Nonradiological inorganics such as iron, magnesium, calcium, potassium, and sodium that are essential nutrients were not included in this risk assessment (EPA 1989). Both radiological and nonradiological COCs are evaluated. The nonradiological COCs evaluated in this risk assessment includes only inorganics because all HE were reported as nondetect.

Nonradiological COCs for Human Health and Ecological Risk Assessment at SWMU 10 are listed in Table 3. Radiological COCs are listed in Table 4. All tables show the associated approved SNL/NM background concentration values (Dinwiddie September 1997, Zamorski December 1997). Discussion of Tables 3 and 4 is provided in Sections VI.4, VII.2, and VII.3.

Table 3
Nonradiological COCs for Human Health and Ecological Risk Assessment at SWMU 10 with Comparison to the Associated SNL/NM Background Screening Value, BCF, Log K_{ow}, and Subpart S Screening Value

COC Name	Maximum Concentration (mg/kg)	SNL/NM Background Concentration (mg/kg)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow}	Bioaccumulator[g] (BCF>40, Log K_{ow}>4)	Subpart S Screening Value[b]	Is Individual COC less than 1/10 of the Action Level?
Arsenic	8.7	9.8	Yes	44[c]	NA	Yes	0.5	No
Barium	250	246	No	170[d]	NA	Yes	6000	Yes
Beryllium	3.4 B	0.75	No	19[c]	NA	No	0.2	No
Cadmium	0.65	0.64	No	64[c]	NA	Yes	80	Yes
Chromium, total[e]	46	18.8	No	16[c]	NA	No	400	No
Lead	30	18.9	No	49[c]	NA	Yes	--	--
Mercury	0.075 J	0.055	No	5500[c]	NA	Yes	20	Yes
Selenium	3.1	3.0	No	800[f]	NA	Yes	400	Yes
Silver	0.61	<0.5	No	0.5[c]	NA	No	400	Yes

[a]From Zamorski (December 1997) Canyon Areas.
[b]IT (July 1994).
[c]BCF and/or Log K_{ow} from Yanicak (March 1997).
[d]BCF from Neumann (1976).
[e]Assumed to be chromium VI for Subpart S screening procedure.
[f]BCF from Callahan et al. (1979).
[g]From NMED (March 1998).

B = Constituent found in blank.
BCF = Bioconcentration factor.
COC = Constituent of concern.
J = Estimated concentration.
K_{ow} = Octanol-water partition coefficient.
Log = Logarithm (base 10).
mg/kg = Milligram(s) per kilogram.
NA = Not applicable.
NMED = New Mexico Environment Department.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid waste management unit.
-- = Information not available.

Table 4
Radiological COCs for Human Health and Ecological Risk Assessment at SWMU 10 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}

COC Name	Maximum Concentration (pCi/g)	SNL/NM Background Concentration (pCi/g)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background[a] Screening Value?	BCF (maximum aquatic)	Bioaccumulator[e] (BCF>40, log K_{ow}>4)
Cs-137	0.54	1.55	Yes	3,000[c]	Yes
Th-232	2.29	1.03	No	3,000[d]	No
U-234[b]	1.05	2.31	Yes	900[d]	Yes
U-235	0.30	0.16	No	900[d]	Yes
U-238	8.41	2.31	No	900[d]	Yes

[a]From Dinwiddie (September 1997) Lower Canyons Area.
[b]U-234 values were calculated using the U-238 concentration and assuming that the U-238 to U-234 ratio was equal to that detected during waste characterization of depleted uranium-contaminated soils generated during the radiological voluntary corrective measures project, where U-234=U-238/8 (Miller June 1998).
[c]BCF from Yanicak (March 1997).
[d]From Baker and Soldat (1992).
[e]Bioaccumulation designation from Yanicak (March 1997).

BCF = Bioconcentration factor.
COC = Constituent of concern.
DU = Depleted uranium.
K_{ow} = Octanol-water partition coefficient.
Log = Logarithm (base 10).
pCi/g = Picocuries per gram.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid waste management unit.

V. Fate and Transport

The primary release of COCs at SWMU 10 was to the surface soil. Wind, water, and biota are natural mechanisms of COC transport from the primary release point. Excavation and removal of the soil is a potential human-caused mechanism of transport. At the surface, the soil may be transported by wind and surface runoff. Because the site is situated between the Manzanita Mountains to the east and the mountains of Manzano Base to the west and is within woodland vegetation, it is protected from strong winds at the ground surface. Therefore, wind is probably not a significant transport mechanism for surface soils.

Water at SWMU 10 is received as precipitation (rain or occasionally snow). Precipitation will either infiltrate or form runoff. Infiltration at the site is enhanced by the coarse textures of the canyon soils (Tesajo-Millett stony sandy loam [USDA June 1977]), but the slopes at this site will produce runoff during intense rainfall events and during extended rainfall periods when soils are near saturation from previous rainfall. Surface runoff is to the ephemeral drainage adjacent to the west side of the site, which is a tributary to the Arroyo del Coyote. Runoff may carry soil particles with adsorbed COCs. The distance of transport will depend upon the size of the particle and the velocity of the water.

Water that infiltrates into the soil will continue to percolate through the soil until field capacity is reached. COCs desorbed from the soil particles into the soil solution may be leached farther into the subsurface soil with this percolation. Runoff from the overlying slopes and evapotranspiration from the soil will limit infiltration potential, making it unlikely to percolate to groundwater. Because none of the COCs at this site have a high potential for leaching in soil, they are highly unlikely to reach groundwater.

Plant roots can take up COCs that are in the soil solution. These COCs may be transported to the above-ground tissues with the xylem stream and may then be consumed by herbivores or returned to the soil as litter. Above-ground litter is capable of transport by wind until consumed by decomposer organisms in the soil. Constituents in plant tissues that are consumed by herbivores may pass through the gut and returned to the soil (at the site or transported from the site in the herbivore) in feces, or may be absorbed and held in tissues, metabolized, or excreted. The herbivore may be eaten by a primary carnivore or scavenger and the constituent still held in the consumed tissues will repeat the sequence of absorption, metabolization, excretion, and consumption by higher predators, scavengers, and decomposers. The potential for transport of the constituents within the food chain is dependent upon the mobility of the species that comprise the food chain and the potential for the constituent to be transferred across the links in the food chain. Because the COCs at SWMU 10 are inorganics, degradation is negligible. Radiological decay will occur in the radionuclides; however, radiological COCs with long half-lives will persist in the environment.

Table 5 summarizes the fate and transport processes that may occur at SWMU 10. COCs at this site are inorganics (metals and radionuclides) in surface and subsurface soil. Wind is not expected to be a significant factor because of the topography and vegetation of the site. Surface runoff may be of moderate significance because of the moderate slopes on the site leading to a nearby ephemeral drainage. Because the COCs are primarily metals, significant leaching deeper into the subsurface soil is also unlikely, and leaching to the groundwater at this site is highly unlikely. Significant food chain transport is unlikely and degradation of the nonradiological COCs will be insignificant. Decay of the radiological COCs will be slow because of the long half-lives of these isotopes.

Table 5
Summary of Fate and Transport at SWMU 10

Transport and Fate Mechanism	Existence at Site	Significance
Wind	Yes	Low
Surface runoff	Yes	Moderate
Migration to groundwater	Unlikely	Very low
Food chain uptake	Yes	Low
Transformation/degradation	Yes	Low

SWMU = Solid waste management unit.

VI. Human Health Risk Screening Assessment

VI.1 Introduction

Human health risk screening assessment of this site includes a number of steps that culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include the following:

Step 1.	Site data are described that provide information on the potential COC, as well as the relevant physical characteristics and properties of the site.
Step 2.	Potential pathways are identified by which a representative population might be exposed to the COCs.
Step 3.	The potential intake of these COCs by the representative population is calculated using a tiered approach. The first component of the tiered approach includes two screening procedures. One screening procedure compares the maximum concentration of the COC to an SNL/NM maximum background screening value. COCs that are not eliminated during the first screening procedure are subjected to a second screening procedure that compares the maximum concentration of the COC to the SNL/NM proposed Subpart S action level.
Step 4.	Toxicological parameters are identified and referenced for COCs that were not eliminated during the screening steps.
Step 5.	Potential toxicity effects (specified as a hazard index [HI]) and excess cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction only occurs when a radiological COC occurs as contamination and exists as a natural background radionuclide.

Step 6.	These values are compared with guidelines established by the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) to determine if further evaluation, and potential site clean-up, is required. Nonradiological COC risk values are also compared to background risk so that an incremental risk may be calculated.
Step 7.	Uncertainties in each of the previous steps are discussed.

VI.2 Step 1. Site Data

The description and history for SWMU 10 is provided in Section I. Comparison of results to data quality objective (DQO) is presented in Section II. The determination of the nature, rate and extent of contamination is described in Section III.

VI.3 Step 2. Pathway Identification

SWMU 10 has been designated a future land-use scenario of industrial although the Citizen's Advisory Board recommends using residential risk-based cleanup levels (DOE and USAF March 1996) (see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for the nonradiological COCs and direct gamma exposure for the radiological COCs. The inhalation pathway for both nonradiological and radiological COCs is included because of the potential to inhale dust. Soil ingestion is included for the radiological COCs as well. No contamination at depth was determined, and therefore no water pathways to the groundwater are considered. Depth to groundwater at SWMU 10 is approximately 180 feet bgs. Because of the lack of perennial surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered not to be significant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land-use scenario. However, plant uptake is considered for the residential land-use scenario.

Pathway Identification

Chemical Constituents	Radiological Constituents
Soil ingestion	Soil ingestion
Inhalation (dust)	Inhalation (dust)
Plant uptake (residential only)	Plant uptake (residential only)
	Direct gamma

VI.4 Step 3. COC Screening Procedures

Step 3 is discussed in this section. This step includes the discussion of two screening procedures. The first screening procedure is a comparison of the maximum COC concentration to the approved background screening level. The second screening procedure compares maximum COC concentrations to SNL/NM proposed Subpart S action levels. This second procedure is only applied to COCs that are not eliminated during the first screening procedure.

VI.4.1 Background Screening Procedure

VI.4.1.1 Methodology

Maximum concentrations of nonradiological COCs are compared to the SNL/NM maximum screening level for this area. SNL/NM has been verbally informed by the New Mexico Environment Department (NMED) that all the metals background values from the Canyons Study (Zamorski December 3, 1997), with the exception of selenium, will be approved (NMED May 1998). Samples have been collected to resolve the selenium background concentration. The SNL/NM maximum background concentration is selected to provide the background screen in Table 3 and used to calculate risk attributable to background in Table 9. Only the COCs that are above their respective SNL/NM background screening level or do not have a quantifiable background screening level are considered in further risk assessment analyses.

For radiological COCs that exceed the SNL/NM background screening levels, background values are subtracted from the individual maximum radionuclide concentrations. Those that do not exceed these background levels are carried no further in the risk assessment. This approach is consistent with DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1993). Radiological COCs that do not have a background value and are detected above the analytical minimum detectable activity are carried through the risk assessment at their maximum levels. The resultant radiological COCs remaining after this step are referred to as background-adjusted radiological COCs.

VI.4.1.2 Background Screening Procedure Results

A comparison of SWMU 10 data to SNL/NM maximum background values (Dinwiddie September 1997; Zamorski December 1997) for Human Health risk assessment is presented in Tables 3 and 4. For the nonradiological COCs, eight constituents have maximum measured values greater than their respective background screening levels.

The maximum concentration value for lead is 30 mg/kg. The EPA intentionally provides no human health toxicological data on lead, and therefore, no risk parameter values can be calculated. However, EPA Region 6 guidance for the screening value for lead for an industrial land-use scenario is 2,000 mg/kg (EPA 1996a); for a residential land-use scenario, the EPA screening guidance value is 400 mg/kg (EPA July 1994). The maximum concentration value for lead at this site is less than both screening values, and therefore, lead is eliminated from further consideration in the human health risk assessment.

For the radiological COCs, three constituents had maximum measured activities greater than their respective background (U-238, U-235, and Th-232). The constituents are attributable to the DU used at the site and the natural Th-232 decay series.

VI.4.2 Subpart S Screening Procedure

VI.4.2.1 Methodology

The maximum concentrations of nonradiological COCs not eliminated during the background screening process were compared with action levels (IT July 1994) calculated using methods and equations promulgated in the proposed RCRA Subpart S (EPA July 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989). Accordingly, all calculations were based upon the assumption that receptor doses from both toxic and potentially carcinogenic compounds result most significantly from ingestion of contaminated soil. Because the samples were all taken from the surface, this assumption is considered valid. If there were ten or fewer COCs and each had a maximum concentration less than 1/10 of the action level, then the site would be judged to pose no significant health hazard to humans. If there were more than ten COCs, the Subpart S screening procedure is not performed.

VI.4.2.2 Results

Table 3 shows the COCs and the associated proposed Subpart S action level. The table compares the maximum concentration values to 1/10 of the proposed Subpart S action level. This methodology was guidance given to SNL/NM from the EPA (EPA 1996b). Two COCs that failed the background screen had concentrations that exceeded 1/10 of the proposed Subpart S action level. Because of these COCs, the site fails the Subpart S screening criteria, and a hazard quotient (HQ) and excess cancer risk value must be calculated for all the COCs.

Radiological COCs have no predetermined action levels analogous to proposed Subpart S levels, and therefore this step in the screening process is not performed for radiological COCs.

VI.5 Step 4. Identification of Toxicological Parameters

Tables 6 (nonradiological) and 7 (radiological) show the COCs retained in the risk assessment and the values for the available toxicological information. The toxicological values used in Table 6 are from the Integrated Risk Information System (IRIS) (EPA 1998), Health Effects Assessment Summary Tables (HEAST) (EPA 1997a), and EPA Region 9 (EPA 1996c) and Region 3 (EPA 1997b) databases. Dose conversion factors (DCF) used in determining the excess TEDE values for the individual pathways were the default values provided in the RESRAD computer code (Yu et al. 1993a) as developed in the following documents:

- DCFs for ingestion and inhalation are taken from "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988).
- DCFs for surface contamination (contamination on the surface of the site) were taken from DOE/EH-0070, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public" (DOE 1988).

Table 6
Toxicological Parameter Values for SWMU 10 Nonradiological COCs

COC Name	RfD_O (mg/kg-d)	Confidence[a]	RfD_{inh} (mg/kg-d)	Confidence[a]	SF_O (mg/kg-day)$^{-1}$	SF_{inh} (mg/kg-day)$^{-1}$	Cancer Class[b]
Barium	7E–2[c]	M	1.4E–4[d]	--	--	--	--
Beryllium	2E–3[c]	L to M	5.7E–6[c]	M	--	8.4E+0[c]	B1
Cadmium	5E–4[c]	H	5.7E–5[d]	--	--	6.3E+0[c]	B1
Chromium III	1E+0[c]	L	5.7E–7[e]	--	--	--	--
Chromium VI	5E–3[c]	L	--	--	--	4.2E+1	A
Mercury	3E–4[f]	--	8.6E–5[c]	M	--	--	D
Selenium	5E–3[c]	H	--	--	--	--	D
Silver	5E–3[c]	L	--	--	--	--	D

[a]Confidence associated with IRIS (EPA 1998a) database values. Confidence: L = low, M = medium, H = high.

[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989) taken from IRIS (EPA 1998a):

A – Human carcinogen.
B1 - Probable human carcinogen. Limited human data are available.
D - Not classifiable as to human carcinogenicity.

[c]Toxicological parameter values from IRIS electronic database (EPA 1998a).
[d]Toxicological parameter values from EPA Region 9 electronic database (EPA 1996c).
[e]Toxicological parameter values from EPA Region 3 electronic database (EPA 1997b).
[f]Toxicological parameter values from HEAST database (EPA 1997a).

COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
HEAST = Health Effects Assessment Summary Tables.
IRIS = Integrated Risk Information System.
mg/kg-day = Milligram(s) per kilogram day.
(mg/kg-day)$^{-1}$ = Per milligram per kilogram day.
RfD_o = Oral chronic reference dose.
RfD_{inh} = Inhalation chronic reference dose.
SF_{inh} = Inhalation slope factor.
SF_o = Oral slope factor.
SWMU = Solid waste management unit.
-- = Information not available.

Table 7
Radiological Toxicological Parameter Values for SWMU 10 COCs Obtained from RESRAD Risk Coefficients[a]

COC Name	SF_o (1/pCi)	Sf_{inh} (1/pCi)	SF_{ev} (g/pCi-yr)	Cancer Class[b]
U-238	6.20E-11	1.20E-08	6.60E-08	A
U-235	4.70E-11	1.30E-08	2.70E-07	A
Th-232	3.30E-11	1.90E-08	2.00E-11	A

[a]From Yu et al. (1993a).
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989): A - human carcinogen.

1/pCi = One per picocurie.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
g/pCi-yr = Gram(s) per picocurie-year.
SF_{ev} = External volume exposure slope factor.
SF_{inh} = Inhalation slope factor.
SF_o = Oral (ingestion) slope factor
SWMU = Solid waste management unit.

- DCFs for volume contamination (exposure to contamination deeper than the immediate surface of the site) were calculated using the methods discussed in "Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil" (Kocher 1983), and ANL/EAIS-8, "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil" (Yu et al. 1993b).

VI.6 Step 5. Exposure Assessment and Risk Characterization

Section VI.6.1 describes the exposure assessment for this risk assessment. Section VI.6.2 provides the risk characterization, including the HI value and the excess cancer risk for both the potential nonradiological COCs and associated background for industrial and residential land uses. The incremental TEDE and incremental estimated cancer risk are provided for the background-adjusted radiological COCs for both industrial and residential land uses.

VI.6.1 Exposure Assessment

Appendix 1 shows the equations and parameter input values used in the calculation of intake values and the subsequent HI and excess cancer risk values for the individual exposure pathways. The appendix shows the parameters for both industrial and residential land-use scenarios. The equations for nonradiological COCs are based upon RAGS (EPA 1989). The parameters are based upon information from RAGS (EPA 1989) as well as other EPA guidance documents and reflect the reasonable maximum exposure (RME) approach advocated by RAGS (EPA 1989). For radiological COCs, the coded equations provided in the RESRAD computer code were used to estimate the incremental TEDE and cancer risk for the individual exposure pathways. Further discussion of this process is provided in *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD*, Version 5.0 (Yu et al. 1993a).

Although the land-use scenario is industrial for this site, the risk and TEDE values for a residential land-use scenario are presented as recommended by the Citizen's Advisory Board.

VI.6.2 Risk Characterization

Table 8 shows that for the SWMU 10 nonradiological COCs, the HI value is 0.01, and the excess cancer risk is 1E-7 for the industrial land-use scenario. The numbers presented included exposure from soil ingestion and dust inhalation for the nonradiological COCs. Table 9 shows that assuming the maximum background concentrations of the SWMU 10 associated background constituents, the HI is 0.00, and the excess cancer risk is 5E-10 for the industrial land-use scenario.

For the radiological COCs, contribution from the direct gamma exposure pathway is included. For the industrial land-use scenario, the most limiting case TEDE was calculated for an individual who spends his workday on the site 50/50 indoors/outdoors on the site. This resulted in an incremental TEDE of 3.8 millirem per year (mrem/yr). In accordance with EPA guidance found in OSWER Directive No. 9200.4-18 (EPA 1997c), an incremental TEDE of 15 mrem/yr is used for the probable land-use scenario (industrial in this case); the calculated dose value for SWMU 10 for the industrial land use is well below this guideline. The estimated excess cancer risk is 5.5E-5.

For the residential land-use scenario nonradiological COC the HI value increases to 2, and the excess cancer risk is 2E-7 (Table 8). The numbers presented included exposure from soil ingestion, dust inhalation, and plant uptake. Although the EPA (1991) generally recommends that inhalation not be included in a residential land-use scenario, this pathway is included because of the potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 9 shows that for the SWMU 10 associated background constituents, the HI is 2, and the excess cancer risk is 1E-9.

For the radiological COCs the incremental TEDE for the residential land-use scenario is 6.8 mrem/yr. The guideline being used is an excess TEDE of 75 mrem/yr (SNL/NM February 1998) for a complete loss of institutional controls (residential land use in this case); the calculated dose value for SWMU 10 for the residential land-use is well below this guideline. Consequently, SWMU 10 is eligible for unrestricted radiological release as the residential land-use scenario resulted in an incremental TEDE to the on-site receptor of less than 75 mrem/yr. The estimated excess cancer risk is 1.1E-4. The excess cancer risk from the nonradiological COCs and the radiological COCs is not additive, as noted in RAGS (EPA 1989).

VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines.

The human health risk assessment analysis evaluated the potential for adverse health effects for both an industrial land-use scenario and a residential land-use scenario.

For the industrial land-use scenario nonradiological COCs, the HI calculated is 0.01 (much less than the numerical guideline of 1 suggested in RAGS [EPA 1989]). Excess cancer risk is estimated at 1E-7. Guidance from the New Mexico Environment Department (NMED) indicates

Table 8
Risk Assessment Values for SWMU 10 Nonradiological COCs

COC Name	Maximum Concentration (mg/kg)	Industrial Land-Use Scenario[a]		Residential Land-Use Scenario[a]	
		HI	Cancer Risk	HI	Cancer Risk
Barium	250	0.00	--	0.04	--
Beryllium	3.4 B	0.00	2E-9	0.01	3E-9
Cadmium	0.65	0.00	2E-10	0.53	4E-10
Chromium, total[b]	46	0.01	1E-7	0.04	2E-7
Mercury	0.075 J	0.00	--	0.13	--
Selenium	3.1	0.00	--	1.09	--
Silver	0.61	0.00	--	0.03	--
TOTAL		**0.01**	**1E-7**	**2**	**2E-7**

[a]EPA (1989).
[b]Chromium, total assumed to be chromium VI (most conservative).
B = Constituent found in blank.
COC = Constituents of concern.
EPA = U.S. Environmental Protection Agency.
HI = Hazard index.
J = Estimated concentration.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid waste management unit.
-- = Information not available.

Table 9
Risk Assessment Values for SWMU 10 Nonradiological Background Constituents

COC Name	Background Concentration[a] (mg/kg)	Industrial Land- Use Scenario[b]		Residential Land- Use Scenario[b]	
		HI	Cancer Risk	HI	Cancer Risk
Barium	246	0.00	--	0.04	--
Beryllium	0.75	0.00	3E-10	0.00	6E-10
Cadmium	0.64	0.00	2E-10	0.52	4E-10
Chromium, total[c]	18.8	0.00	--	0.01	--
Mercury	0.055	0.00	--	0.09	--
Selenium	3.0	0.00	--	1.06	--
Silver	<0.5	--	--	--	--
TOTAL		**0.00**	**5E-10**	**2**	**1E-9**

[a]From Zamorski (December 1997, Lower Canyons Area).
[b]EPA (1989).
[c]Chromium, total assumed to be chromium III
COC = Constituents of concern.
EPA = U.S. Environmental Protection Agency.
HI = Hazard index.
SWMU = Solid waste management unit.
mg/kg = Milligram(s) per kilogram.
-- = Information not available.

that excess lifetime risk of developing cancer by an individual must be less than 1E-6 for Class A and B carcinogens and less than 1E-5 for Class C carcinogens (NMED March 1998). The excess cancer risk is driven by chromium, total. Chromium, total is assumed to be chromium VI (most conservative) which is a Class A carcinogen. Thus, the total excess cancer risk for this site is below the suggested acceptable risk value of 1E-6. This assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land-use scenarios. For nonradiological COCs, assuming the industrial land-use scenario, the HI is 0.00. The excess cancer risk is 5E-10. Incremental risk is determined from subtracting risk associated with background from potential COC risk. These numbers are not rounded before the difference is determined and therefore may appear to be inconsistent with numbers presented in tables and within the text. The incremental HI is 0.01, and the incremental cancer risk is 1E-7 for the industrial land-use scenario. These incremental risk calculations indicate risk below the proposed NMED guidelines considering an industrial land-use scenario.

For radiological COCs of the industrial land-use scenario, incremental TEDE is 3.8 mrem/yr, which is significantly less than the EPA's numerical guideline of 15 mrem/yr. Incremental estimated excess cancer risk is 5.5E-5.

For the residential land-use scenario nonradiological COCs, the calculated HI is 2, which is above the numerical guidance. The excess cancer risk is estimated at 2E-7. The excess cancer risk is again driven by chromium, total (assumed to be chromium VI) which is a Class A carcinogen. Therefore, the total excess cancer risk for this site is below the suggested acceptable risk value of 1E-6. The HI for associated background for the residential land-use scenario is 2. The excess cancer risk is 1E-9. The incremental HI is 0.15, and the incremental cancer risk is 2E-7 for the residential land-use scenario. These incremental risk calculations indicate insignificant risk considering a residential land-use scenario.

The incremental TEDE for a residential land-use scenario from the radiological components is 6.8 mrem/yr, which is significantly less than the numerical guideline of 75 mrem/yr suggested in SNL/NM RESRAD Input Parameter Assumptions and Justification (SNL/NM February 1998). The estimated excess cancer risk is 1.1E-4.

VI.8 Step 7. Uncertainty Discussion

The determination of the nature, rate, and extent of contamination at SWMU 10 was based upon an initial conceptual model validated with confirmatory sampling conducted at the site. The confirmatory sampling was implemented in accordance with the Sampling and Analysis Plan (SNL/NM March 1997) and Bullets of Understanding relating to the sampling (NMED DOE OB April 1997). The DQOs contained in the Sampling and Analysis Plan (SNL/NM March 1997) are appropriate for use in screening risk assessments. The data collected, based upon sample location, density, and depth, are representative of the site. The analytical requirements and results satisfy the DQOs. Data quality were validated in accordance with SNL/NM procedures (SNL/NM July 1994). Therefore, there is no uncertainty associated with the data quality used to perform the screening risk assessment at SWMU 10. HE was not detected in any of the soil, sediment, and quality assurance and quality control samples analyzed.

Because of the location, history of the site, future and recommended land-use scenarios (DOE and USAF March 1996), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in making the risk assessment analysis. Because the COCs are found in surface and near-surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values. This means that parameter values used in calculations were conservative and that the calculated intakes are likely overestimates. Maximum measured values of the concentrations of the COCs were used to provide conservative results.

Table 4 shows the uncertainties (confidence) in nonradiological toxicological parameter values. There is a mixture of estimated values and values from IRIS (EPA 1998), HEAST (EPA 1997a), EPA Region 9 (EPA 1996c) and EPA Region 3 (EPA 1997b) databases. Where values are not provided, information is not available from the HEAST (1997a), IRIS (EPA 1998), or the EPA regions (EPA 1996c, 1997b). Because of the conservative nature of the RME approach, uncertainties in toxicological values are not expected to be of high enough concern to change the conclusion from the risk assessment analysis.

The risk assessment values for the nonradiological COCs are within the human health acceptable range for the industrial land-use scenario compared to the established numerical guidance. The incremental risk assessment values for the residential land-use scenario are also below the NMED numerical guidance.

For the radiological COCs, the conclusion of the risk assessment is that potential effects on human health, for both industrial and residential land-use scenarios are within guidelines and are a small fraction of the estimated 360 mrem/yr received by the average U.S. population (NCRP 1987).

The overall uncertainty in all of the steps in the risk assessment process is considered not significant with respect to the conclusion reached.

VI.9 Summary

SWMU 10 has identified COCs consisting of some inorganic and radiological compounds. Because of the location of the site, the use of both industrial and residential land-use scenarios, and the nature of contamination, potential exposure pathways identified for this site included soil ingestion and dust inhalation for nonradiological inorganic constituents and soil ingestion, dust inhalation, and direct gamma exposure for radiological exposure. Plant uptake was included as an exposure pathway for the residential land-use scenario.

Using conservative assumptions and employing an RME approach to risk assessment, calculations for nonradiological COCs show that for the industrial land-use scenario the HI of 0.01 is significantly less than the accepted numerical guidance from the EPA. The excess cancer risk of 1E-7 is also below the acceptable risk value provided by the NMED for an industrial land-use (NMED March 1998). The incremental HI is 0.01, and the incremental cancer risk is 1E-7 for the industrial land-use scenario. Risk calculations indicate insignificant risk to human health considering an industrial land-use scenario.

Incremental TEDE and corresponding estimated cancer risk from radiological COCs are much less than EPA guidance values; the estimated TEDE is 3.8 mrem/yr for the industrial land-use scenario. This value is much less than the numerical guidance of 15 mrem/yr in EPA guidance (EPA 1997c). The corresponding incremental estimated cancer risk value is 5.5E-5 for the industrial land-use scenario.

Using conservative assumptions and employing an RME approach to the risk assessment, the calculations for the nonradiological COCs show that for the residential land-use scenario the HI of 2 is greater than the accepted numerical guidance from the EPA. The excess cancer risk of 2E-7 is below the acceptable risk value provided by the NMED for a residential land-use (NMED March 1998). The incremental HI is 0.15, and the incremental cancer risk is 2E-7 for the residential land-use scenario. Incremental risk calculations indicate insignificant risk to human health for a residential land-use scenario.

The incremental TEDE and corresponding estimated cancer risk from the radiological COCs are much less than EPA guidance values; the estimated TEDE is 6.8 mrem/yr for the residential land-use scenario. This value is much less than the numerical guidance of 75 mrem/yr in SNL/NM RESRAD Input Parameter Assumptions and Justification (SNL/NM February 1998). The corresponding incremental estimated cancer risk value is 1.1E-4 for the residential land-use scenario. Therefore, SWMU 10 is eligible for unrestricted radiological release.

The uncertainties associated with the calculations are considered small relative to the conservativeness of the risk assessment analysis. It is, therefore, concluded that this site does not have potential to affect human health under an industrial land-use scenario.

VII. Ecological Risk Screening Assessment

VII.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) in soils at SWMU 10, (Burial Mounds). A component of the NMED Risk-Based Decision Tree is to conduct an ecological screening assessment that corresponds with that presented in the EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997d). The current methodology is tiered and contains an initial scoping assessment followed by a more detailed screening assessment. Initial components of NMED's decision tree (a discussion of DQOs, a data assessment, and evaluations of bioaccumulation and fate-and-transport potential) are addressed in the scoping assessment (Section VII.2 of this report), with the exception of DQOs which are reviewed in Section II of this report. Following the completion of the scoping assessment, a determination is made as to whether a more detailed examination of potential ecological risk is necessary. If deemed necessary, the scoping assessment proceeds to a screening assessment whereby a more quantitative estimate of ecological risk is conducted. Although this assessment incorporates conservatisms in the estimation of ecological risks, ecological relevance and professional judgment are also used as recommended by the EPA (1998b) to ensure that predicted exposures of selected ecological receptors reflect those reasonably expected to occur at the site.

VII.2 Scoping Assessment

The scoping assessment focuses primarily on the likelihood of exposure of biota at or adjacent to the site to be exposed to constituents associated with site activities. Included in this section are an evaluation of existing data and a comparison of maximum detected concentrations to background concentrations, examination of bioaccumulation potential, and fate and transport potential. A Scoping Risk Management Decision will involve a summary of the scoping results and a determination as to whether further examination of potential ecological impacts is necessary.

VII.2.1 Data Assessment

As indicated in Section IV (Tables 3 and 4), constituents in soil within the 0- to 5-foot-depth interval that exceeded background concentrations were as follows:

- Barium
- Beryllium
- Cadmium
- Chromium (total)

- Lead
- Mercury
- Selenium
- Silver
- Th-232
- U-235
- U-238.

No organic analytes were detected in soil.

VII.2.2 Bioaccumulation

Among the COPECs listed in Section VII.2.1, the following were considered to have bioaccumulation potential in aquatic environments (Section IV, Tables 3 and 4):

- Barium
- Cadmium
- Lead
- Mercury
- Selenium
- U-235
- U-238.

It should be noted, however, that as directed by the NMED (NMED March 1998), bioaccumulation for inorganics is assessed exclusively based upon maximum reported bioconcentration factors (BCF) for aquatic species. Because only aquatic BCFs are used to evaluate the bioaccumulation potential for metals, bioaccumulation in terrestrial species is likely to be overpredicted.

VII.2.3 Fate and Transport Potential

The potential for the COPECs to move from the source of contamination to other media or biota is discussed in Section V. As noted in Table 3 (Section V), surface-water runoff is expected to be of moderate significance, while significant wind dispersion, transformation, and degradation are expected to be low. Food-chain uptake is expected to be of moderate to low significance. Migration to groundwater is not anticipated.

VII.2.4 Scoping Risk Management Decision

Based upon information gathered through the scoping assessment, it was concluded that complete ecological pathways may be associated with this SWMU and that COPECs also exist at the site. As a consequence, a screening assessment was deemed necessary to predict the potential level of ecological risk associated with the site.

VII.3 Screening Assessment

As concluded in Section VII.2.4, complete ecological pathways and COPECs are associated with this SWMU. The screening assessment performed for the site involves a quantitative estimate of current ecological risks using exposure models in association with exposure parameters and toxicity information obtained from the literature. The estimation of potential ecological risks is conservative to ensure ecological risks are not underpredicted.

Components within the screening assessment include the following:

- Problem Formulation—sets the stage for the evaluation of potential exposure and risk.
- Exposure Estimation—provides a quantitative estimate of potential exposure.
- Ecological Effects Evaluation—presents benchmarks used to gauge the toxicity of COPECs to specific receptors.
- Risk Characterization—characterizes the ecological risk associated with exposure of the receptors to environmental media at the site.
- Uncertainty Assessment—discusses uncertainties associated with the estimation of exposure and risk.
- Risk Interpretation—evaluates ecological risk in terms of HQs and ecological significance.
- Screening Assessment Scientific/Management Decision Point—presents the decision to risk managers based upon the results of the screening assessment.

VII.3.1 Problem Formulation

Problem Formulation is the initial stage of the screening assessment that provides the introduction to the risk evaluation process. Components that are addressed in this section include a discussion of ecological pathways and the ecological setting, identification of COPECs, and selection of ecological receptors. The conceptual model, ecological food webs, and ecological endpoints (other components commonly addressed in a screening assessment) are presented in the "Predictive Ecological Risk Assessment Methodology for SNL/NM ER [Environmental Restoration] Program" (IT July 1998) and are not duplicated here.

VII.3.1.1 Ecological Pathways and Setting

SWMU 10 is located about 1.8 miles north of the Coyote Springs between the Manzanita Mountains and the Four Hills (Manzano Base). The site occupies an area approximately 400 feet in diameter and contains SWMU 60 within its boundary. The site was formerly comprised of soil mounds containing testing debris from the TABS test. Subsequent VCM activity at the site have removed all primary sources of COPECs. The site is located within piñon-juniper woodland vegetation, with an understory dominated by blue grama (*Bouteloua gracilis*). The terrain is rolling, and the soil is coarse to rocky. The shallow subsurface geology is comprised of a thin layer of alluvial sediments overlying granitic bedrock. This area of SNL/NM is characterized by considerable structural complexity in the subsurface. Several major fault systems intersect the general area. Site-specific depth to groundwater is unknown, but is considered to be approximately 180 feet bgs. The water table may occur in unconsolidated material but most likely occurs in fractured bedrock. The site is immediately adjacent to an arroyo that flows south, entering the Arroyo del Coyote below the Coyote Springs. There is no wetland or aquatic habitat on the site or along this arroyo. SWMU 10 was surveyed for sensitive species on April 26 and May 24, 1994 (IT February 1995). No sensitive species were found within the current boundaries of the site.

Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and subsurface soil. Direct uptake of COPECs from soil was assumed to be the major route of exposure for plants, with exposure of plants to wind-blown soil assumed to be minor. Exposure modeling for the wildlife receptors was limited to the food and soil ingestion pathways. Because of the lack of surface water at this site, exposure to COPECs through the ingestion of surface water was considered insignificant. Inhalation and dermal contact were also considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Groundwater is not expected to be affected by COPECs at this site.

VII.3.1.2 COPECs

Historically, activities at SWMU 10 included tests involving DU, beryllium, HE, and radioactive tracers (osmium and others). Based upon confirmatory sampling following the VCM activities, the COPECs at SWMU 10 include metals and DU.

In order to provide conservatism in this ecological risk assessment, the assessment is based upon the maximum soil concentrations of the COPECs as measured in soil samples within the first 5 feet of soil. Both radiological and nonradiological COPECs are evaluated. The nonradiological COCs consist of inorganic analytes (i.e., metals). No organic analytes were detected in these soil samples. Inorganic analytes and radionuclides were screened against background concentrations, and those that exceeded the approved SNL/NM background screening levels (Dinwiddie September 1997; Zamorski December 1998) for the area were considered to be COPECs. Maximum COPEC concentrations are reported in Tables 3 and 4. Nonradiological inorganics that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment as set forth by the EPA (1989).

VII.3.1.3 Ecological Receptors

A nonspecific perennial plant was selected as the receptor to represent plant species at the site (IT July 1998). Vascular plants are the principal primary producers at the site and are key to the diversity and productivity of the wildlife community associate with the site. A deer mouse (*Peromyscus maniculatus*) and burrowing owl (*Speotyto cunicularia*) were used to represent wildlife use. Because of its opportunistic food habits, the deer mouse was used to represent a mammalian herbivore, omnivore, and insectivore. The burrowing owl was selected as the top predator. The burrowing owl is present at SNL/NM and is designated a species of management concern by the U.S. Fish and Wildlife Service in Region 2, which includes the state of New Mexico (USFWS September 1995).

VII.3.2 Exposure Estimation

Direct uptake of COPECs from the soil was considered the only significant route of exposure for terrestrial plants. Exposure modeling for the wildlife receptors exposed to nonradioactive and radioactive COPECs was limited to food and soil ingestion pathways with external dose included for radiation exposure only (IT July 1998). Inhalation and dermal contact were considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Drinking water was also considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled under three dietary regimes: as an herbivore (100 percent of its diet as plant material), as an omnivore (50 percent of its diet as plants and 50 percent as soil invertebrates), and as an insectivore (100 percent of its diet as soil invertebrates). The burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Because the exposure in the burrowing owl from a diet consisting of equal parts of herbivorous, omnivorous, and insectivorous mice would be equivalent to the exposure consisting of only omnivorous mice, the diet of the burrowing owl was modeled with intake of omnivorous mice only. Both species were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 10 presents the species-specific factors used in modeling exposures in the wildlife receptors. Justification for use of the factors presented in this table is described in the ecological risk assessment methodology document (IT July 1998).

Although home range is also included in this table, exposures for this risk assessment were modeled using an area use factor of 1, implying that all food items and soil ingested are from the site being investigated. The maximum measured COPEC concentrations from surface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site.

For the radiological dose rate calculations, the deer mouse was modeled as an herbivore (100 percent of its diet as plants), and the burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Both were modeled with soil ingestion comprising 2 percent of the total dietary intake. Receptors are exposed to radiation both internally and externally from U-235, U-238, and Th-232. Internal and external dose rates to the deer mouse and burrowing owl are approximated using modified dose rate models from the *Hanford Site Risk Assessment Methodology* (DOE 1995) as presented in the ecological risk assessment methodology document for the SNL/NM ER Program (IT July 1998). Radionuclide-dependent data for the dose rate calculations were obtained from Baker and Soldat (1992). The external dose rate model examines the total-body dose rate to a receptor residing in soil exposed to radionuclides. The soil surrounding the receptor is assumed to be an infinite medium uniformly contaminated with gamma-emitting radionuclides. The external dose rate model is the same for both the deer mouse and the burrowing owl. The internal total-body dose rate model assumes that a fraction of the radionuclide concentration ingested by a receptor is absorbed by the body and concentrated at the center of a spherical body shape. This provides for a conservative estimate for absorbed dose. This concentrated radiation source at the center of the body of the receptor is assumed to be a "point" source. Radiation emitted from this point source is absorbed by the body tissues to contribute to the absorbed dose. Alpha and beta emitters are assumed to transfer 100 percent of their energy to the receptor as they pass through tissues. Gamma-emitting radionuclides only transfer a fraction of their energy to the tissues because gamma rays interact less with matter than do beta or alpha emitters. The

Table 10
Exposure Factors for Ecological Receptors at SWMU 10

Receptor Species	Class/Order	Trophic Level	Body Weight (kg)[a]	Food Intake Rate (kg/day)[b]	Dietary Composition[c]	Home Range (acres)
Deer Mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Herbivore	2.39E-2[d]	3.72E-3	Plants: 100% (+ Soil at 2% of intake)	2.7E-1[e]
Deer Mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Omnivore	2.39E-2[d]	3.72E-3	Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake)	2.7E-1[e]
Deer Mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Insectivore	2.39E-2[d]	3.72E-3	Invertebrates: 100% (+ Soil at 2% of intake)	2.7E-1[e]
Burrowing owl (*Speotyto cunicularia*)	Aves/ Strigiformes	Carnivore	1.55E-1[f]	1.73E-2	Rodents: 100% (+ Soil at 2% of intake)	3.5E+1[g]

[a]Body weights are in kilograms wet weight.
[b]Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.
[c]Dietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.
[d]From Silva and Downing (1995).
[e]EPA (1993), based upon the average home range measured in semiarid shrubland in Idaho.
[f]From Dunning (1993).
[g]From Haug et al. (1993).

EPA = U.S. Environmental Protection Agency.
kg = Kilogram(s).
kg/day = Kilogram(s) per day.
SWMU = Solid waste management unit.

external and internal dose rate results are summed to calculate a total dose rate caused by exposure to radionuclides in soil.

Table 11 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 12 presents maximum concentrations in soil and derived concentrations in tissues of the various food-chain elements that are used to model dietary exposures for each of the wildlife receptors.

VII.3.3 Ecological Effects Evaluation

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 13. For plants, the benchmark soil concentrations are based upon the lowest-observed-adverse-effect level (LOAEL). For wildlife, the toxicity benchmarks are based upon the no-observed-adverse-effect level (NOAEL) for chronic oral exposure in a taxonomically similar test species. Insufficient toxicity information was found to estimate the LOAELs or NOAELs for some COPECs for terrestrial plant life and wildlife receptors, respectively.

The benchmark used for exposure of terrestrial receptors to radiation was 0.1 rad/day. This value has been recommended by the International Atomic Energy Agency (IAEA 1992) for the protection of terrestrial populations. Because plants and insects are less sensitive to radiation than vertebrates (Whicker and Schultz 1982), the dose of 0.1 rad per day should also offer sufficient protection to other components within the terrestrial habitat of SWMU 10.

VII.3.4 Risk Characterization

Maximum concentrations in soil and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. Results of these comparisons are presented in Table 14. HQs are used to quantify the comparison with benchmarks for plants and wildlife exposure.

Analytes with HQs exceeding unity for plants were chromium (total) and selenium. Barium resulted in an HQ in excess of unity for the omnivorous and insectivorous deer mouse. Selenium resulted in an HQ greater than 1.0 for the insectivorous deer mouse. One analyte, mercury (organic), resulted in an HQ greater than 1.0 for the burrowing owl, although HQs for the burrowing owl could not be determined for beryllium and silver. As directed by the NMED, HIs were calculated for each of the receptors (the HI is the sum of chemical-specific HQs for all pathways for a given receptor). All receptors had HIs greater than unity, with a maximum HI of 45 for plants.

Tables 15 and 16 summarize the internal and external dose rate model results for the six radionuclides. The total radiation dose rate to the deer mouse was predicted to be 5.4E-4 rad/day. Total dose rate to the burrowing owl was predicted to be 4.9E-4 rad/day. The external dose rate from exposure to these radionuclides for both receptors is the primary contributor to the total dose rate. The dose rates for the deer mouse and the burrowing owl are considerably less than the benchmark of 0.1 rad/day.

Table 11
Transfer Factors Used in Exposure Models for Constituents of Potential Ecological Concern at SWMU 10

Constituent of Potential Ecological Concern	Soil-to-Plant Transfer Factor	Soil-to-Invertebrate Transfer Factor	Food-to-Muscle Transfer Factor
Inorganic			
Barium	1.5E-1[a]	1.0E+0[b]	2.0E-4[c]
Beryllium	1.0E-2[a]	1.0E+0[b]	1.0E-3[a]
Cadmium	5.5E-1[a]	6.0E-1[d]	5.5E-4[a]
Chromium (total)	4.0E-2[c]	1.3E-1[e]	3.0E-2[c]
Lead	9.0E-2[c]	4.0E-2[d]	8.0E-4[c]
Mercury	1.0E+0[c]	1.0E+0[b]	2.5E-1[a]
Selenium	5.0E-1[c]	1.0E+0[b]	1.0E-1[c]
Silver	1.0E+0[c]	2.5E-1[d]	5.0E-3[c]

[a]From Baes et al. (1984).
[b]Default value.
[c]NCRP (January 1989).
[d]From Stafford et al. (1991).
[e]From Ma (1982).
SWMU = Solid waste management unit.

Table 12
Media Concentrations[a] for Constituents of Potential Ecological Concern at SWMU 10

Constituent of Potential Ecological Concern	Soil (maximum)	Plant Foliage[b]	Soil Invertebrate[b]	Deer Mouse Tissues[c]
Inorganic				
Barium	2.5E+2	3.8E+1	2.5E+2	9.3E-2
Beryllium	3.4E+0	3.4E-2	3.4E+0	5.6E-3
Cadmium	6.5E-1	3.6E-1	3.9E-1	6.7E-4
Chromium (total)	4.6E+1	1.8E+0	6.0E+0	4.5E-1
Lead	3.0E+1	2.7E+0	1.2E+0	6.0E-2
Mercury	0.075 J	7.5E-2	7.5E-2	6.0E-2
Selenium	3.1E+0	1.6E+0	3.1E+0	7.5E-1
Silver	6.1E+1	6.1E-1	1.5E-1	6.2E-3

[a]In milligrams per kilogram. All are based upon dry weight of the media.
[b]Product of the soil concentration and the corresponding transfer factor.
[c]Based upon the deer mouse with an omnivorous diet. Product of the average concentration in food times the food-to-muscle transfer factor times the wet weight-dry weight conversion factor of 3.125 (from EPA 1993).
SWMU = Solid waste management unit.

Table 13
Toxicity Benchmarks for Ecological Receptors at SWMU 10

		Mammalian NOAELs			Avian NOAELs		
Constituent of Potential Ecological Concern	Plant Benchmark[a,b]	Mammalian Test Species[c,d]	Test Species NOAEL[d,e]	Deer Mouse NOAEL[e,f]	Avian Test Species[d]	Test Species NOAEL[d,e]	Burrowing Owl NOAEL[e,g]
Inorganic							
Barium	500	Rat[h]	5.1	10.5	Chicks	20.8	20.8
Beryllium	10	Rat	0.66	1.29	---[i]	---	---
Cadmium	3	Rat[j]	1.0	1.9	Mallard	1.45	1.45
Chromium (total)	1	Rat	2,737	5,354	Black duck	1.0	1.0
Lead	50	Rat	8.0	15.6	American kestrel	3.85	3.85
Mercury (inorganic)	0.3	Mouse	13.2	14.0	Japanese quail	0.45	0.45
Mercury (organic)	0.3	Rat	0.032	0.063	Mallard	0.0064	0.0064
Selenium	1	Rat	0.20	0.39	Screech owl	0.44	0.44
Silver	2	Rat	17.8	34.8	---	---	---

[a]In milligrams per kilogram soil.
[b]From Will and Suter (1995).
[c]Body weights (in kilograms) for the no-observed-adverse-effect level (NOAEL) conversion are as follows: lab mouse, 0.030; lab rat, 0.350 (except where noted).
[d]From Sample et al. (1996), except where noted.
[e]In milligrams per kilogram body weight per day.
[f]Based upon NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.0239 kilogram and a mammalian scaling factor of 0.25.
[g]Based upon NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.
[h]Body weight: 0.435 kilogram.
[i]--- designates insufficient toxicity data.
[j]Body weight: 0.303 kilogram.
SWMU = Solid waste management unit.
NOAELs = No-observed-adverse-effect levels.

Table 14
Hazard Quotients for Ecological Receptors at SWMU 10

Constituent of Potential Ecological Concern	Plant HQ[a]	Deer Mouse HQ (Herbivorous)[a]	Deer Mouse HQ (Omnivorous)[a]	Deer Mouse HQ (Insectivorous)[a]	Burrowing Owl HQ[a]
Inorganic					
Barium	5.0E-1	6.3E-1	**2.2E+0**	**3.8E+0**	2.7E-2
Beryllium	3.4E-1	1.2E-2	2.2E-1	4.2E-1	---
Cadmium	2.2E-1	3.1E-2	3.2E-2	3.3E-2	1.1E-3
Chromium (total)	**4.6E+1**	8.0E-5	1.4E-4	2.0E-4	1.5E-1
Lead	6.0E-1	3.3E-2	2.5E-2	1.8E-2	1.8E-2
Mercury (inorganic)	2.5E-1	8.5E-4	8.5E-4	8.5E-4	1.5E-2
Mercury (organic)	2.5E-1	1.9E-1	1.9E-1	1.9E-1	**1.1E+0**
Selenium	**3.1E+0**	6.4E-1	9.5E-1	**1.3E+0**	2.1E-1
Silver	3.1E-1	2.8E-3	1.8E-3	7.4E-4	---
HI[c]	**5.1E+1**	**1.5E+0**	**3.6E+0**	**5.8E+0**	**1.5E+0**

[a]**Bold** text indicates HQ or HI exceeds unity.
[c]The HI is the sum of individual HQs using the value for organic mercury as a conservative estimate of the HI.
HI = Hazard index.
HQ = Hazard quotient..
SWMU = Solid waste management unit.
--- designates insufficient toxicity data available for risk estimation purposes.

Table 15
Internal and External Dose Rates for
Deer Mice Exposed to Radionuclides at SWMU 10

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
U-235[a]	3.0E-1	3.3E-6	4.9E-6	8.2E-6
U-238	8.4E+0	8.5E-5	1.7E-5	1.0E-4
Th-232	2.3E+0	9.2E-7	4.3E-4	4.3E-4
Total		8.9E-5	4.5E-4	5.4E-4

[a]The U-235 value was calculated using the U-238 concentration and assuming that the U-238 to U-235 ratio was equal to that detected during waste characterization of depleted uranium-contaminated soils generated during the radiological voluntary corrective measures project, where U-235=U-238/73 (Miller June 1998).
pCi/g = Picocurie(s) per gram.
SWMU = Solid waste management unit.

Table 16
Internal and External Dose Rates for
Burrowing Owls Exposed to Radionuclides at SWMU 10

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
U-235[a]	3.0E-1	1.3E-6	4.9E-6	6.2E-6
U-238	8.4E+0	3.4E-5	1.7E-5	5.1E-5
Th-232	2.3E+0	1.3E-6	4.3E-4	4.3E-4
Total		3.7E-5	4.5E-4	4.9E-4

[a]The U-235 value was calculated using the U-238 concentration and assuming that the U-238 to U-235 ratio was equal to that detected during waste characterization of depleted uranium-contaminated soils generated during the radiological voluntary corrective measures project, where U-235=U-238/73 (Miller June 1998).

VII.3.5 Uncertainty Assessment

Many uncertainties are associated with the characterization of ecological risks at SWMU 10. These uncertainties result from assumptions used in calculating risk that may overestimate or underestimate true risk presented at a site. For this risk assessment, assumptions are made that are more likely to overestimate exposures and risk rather than to underestimate them. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the site. Conservatisms incorporated into this risk assessment include the use of maximum measured analyte concentrations in soil to evaluate risk, the use of wildlife toxicity benchmarks based upon NOAEL values, the incorporation of strict herbivorous and strict insectivorous diets for predicting the extreme HQ values for the deer mouse, and the use of 1.0 as the area use factor for wildlife receptors regardless of seasonal use or home range size. Each of these uncertainties, which are consistent among each of the SWMU-specific ecological risk assessments, is discussed in greater detail in the uncertainty section of the ecological risk assessment methodology document for the SNL/NM ER Program (IT July 1998).

Uncertainties associated with the estimation of risk to ecological receptors following exposure to U-235, U-238, and Th-232 are primarily related to those inherent in the radionuclide-specific data. Radionuclide-dependent data are measured values that have their associated errors, which are typically negligible. The dose rate models used for these calculations are based upon conservative estimates on receptor shape, radiation absorption by body tissues, and intake parameters. The goal is to provide a realistic but conservative estimate of a receptor's exposure to radionuclides in soil, both internally and externally.

One large uncertainty associated with the prediction of ecological risks at this site is the use of the maximum measured concentrations in soil to evaluate risk. This results in a conservative exposure scenario that does not necessarily reflect actual site conditions. This is also true with regard to the use of detection limits in the estimation of risk. The assumption of an area use factor of 1.0 is a source of uncertainty for the burrowing owl. Because SWMU 10 is less than 3 acres in size, an area use factor of less than 0.1 would be justified for this receptor. This is sufficient to reduce the HQ for mercury well below unity.

Analytical data were examined more closely to assess variability within the data. Exclusion of these data results in maximum chromium and barium concentrations of 40 and 250 mg/kg, respectively. Utilization of 40 mg/kg chromium concentration in the estimation of risks to plants results in an HQ of 40. The average chromium within this data set, however, is only 12.0 mg/kg, which is less than background. Consequently, risks to plant communities on site from exposure to chromium are not expected to be significant. Risk was also predicted for deer mice exposed to barium. Utilization of the average barium concentration of 109 mg/kg results in an HQ of greater than (1.6) for the insectivorous mouse alone. Risks to ecological receptors from exposure to chromium and barium on-site are, therefore, expected to be low. Selenium was also predicted to be potentially hazardous to plants and the insectivorous mice at the site. Exposure of plants at this site to the average detected concentration would result in an HQ of 1.1 for the plant and less than unity for the deer mouse. Mercury resulted in an HQ of greater than 1.0; however, it was detected in less than 7 percent of the samples. This only occurs if mercury is assumed to be entirely in the organic form. Consideration of the nondetected values would lower the HQ to below 0 for plants at the site. Based upon this analysis, chromium, barium, selenium, and mercury are not expected to pose a significant risk to biota associated with the site.

In the estimation of ecological risk, background concentrations are included as a component of maximum on-site concentrations. Table 17 illustrates risk estimates associated with exposure of each of the receptors to background concentrations of the metal COPECs. With respect to the plant, an HQ greater than 1.0 was obtained for chromium (total) and selenium. HQs greater than unity were also obtained for the omnivorous and insectivorous deer mouse exposed to barium. Selenium also resulted in an HQ greater than 1.0 for the insectivorous deer mouse. No HQs greater than 1.0 were reported for the burrowing owl from background exposure. Although less than 50 percent of the maximum on-site total chromium soil concentration was associated with background, 97 percent of the maximum on-site total selenium concentration was associated with background. Likewise, 98 percent of the maximum on-site barium concentration and 73 of the maximum on-site mercury concentration were associated with background. Average on-site concentrations of barium, chromium, and selenium are within the range of background concentrations. Because of the uncertainties associated with exposure and toxicity, it is unlikely that selenium, chromium, and barium, with exposure concentrations largely attributable to background, present significant ecological risk.

Based upon this uncertainty analysis, ecological risks at SWMU 10 are expected to be very low. HQs greater than unity were initially predicted; however, closer examination of the exposure assumptions revealed an overestimation of risk primarily attributed to exposure concentration, background risk, quality of analytical data, and the assumption of mercury as entirely in the organic form.

VII.3.6 Risk Interpretation

Ecological risks associated with SWMU 10 were estimated through a screening assessment that incorporated site-specific information when available. Overall, ecological risks to plants are expected to be low because of the fact that predicted risks associated with exposure to barium, chromium (total), selenium, and mercury are based upon calculations using maximum detected values. With respect to the deer mouse, risk is also expected to be low. In addition, average barium, chromium, and selenium concentrations at the site were within the range of background concentrations. Mercury was predicted to be hazardous to the burrowing owl. Potential risks associated with mercury for the burrowing owl were evaluated using maximum detected values, an assumption that the concentration was entirely in an organic form, and an area use factor of 1.0, all of which can account for the HQ exceeding unit. Based upon this final analysis, ecological risks associated with SWMU 10 are expected to be very low.

VII.3.7 Screening Assessment Scientific/Management Decision Point

Once potential ecological risks associated with the site have been assessed, a decision is made as whether the site should be recommended for NFA or additional data should be collected to more thoroughly assess actual ecological risk at the site. With respect to this site, ecological risks were predicted to be very low. The scientific/management decision is to recommend this site for NFA.

Table 17
HQs for Ecological Receptors Exposed to Background Concentrations for SWMU 10

Constituent of Potential Ecological Concern	Plant HQ[a]	Deer Mouse HQ (Herbivorous)[a]	Deer Mouse HQ (Omnivorous)[a]	Deer Mouse HQ (Insectivorous)[a]	Burrowing Owl HQ[a]
Inorganic					
Barium	4.9E-1	6.2E-1	**2.2E+0**	**3.7E+0**	2.7E-2
Beryllium	7.5E-2	2.7E-3	4.8E-2	9.2E-2	---[b]
Cadmium	2.1E-1	3.0E-2	3.1E-2	3.3E-2	1.0E-3
Chromium (total)	**1.9E+1**	3.3E-5	5.7E-5	8.2E-5	6.3E-2
Lead	3.8E-1	2.1E-2	1.6E-2	1.1E-2	1.1E-2
Mercury (inorganic)	1.8E-1	6.3E-4	6.3E-4	6.3E-4	1.1E-2
Mercury (organic)	1.8E-1	1.4E-1	1.4E-1	1.4E-1	7.8E-1
Selenium	**3.0E+0**	6.2E-1	9.2E-1	**1.2E+0**	2.0E-1
Silver	1.3E-1	1.1E-3	7.2E-4	3.0E-4	---
HI[c]	**2.3E+1**	**1.4E+0**	**3.4E+0**	**5.2E+0**	**1.1E+0**

[a] **Bold** text indicates HQ or HI exceeds unity.
[b] --- designates insufficient toxicity data available for risk estimation purposes.
[c] The HI is the sum of individual HQs using the value for organic mercury as a conservative estimate of the HI.
HI = Hazard index.
HQ = Hazard quotients.

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APPENDIX 1
EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

Sandia National Laboratories (SNL/NM) proposes that a default set of exposure routes and associated default parameter values be developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM solid waste management units (SWMU) have similar types of contamination and physical settings, SNL/NM believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL/NM views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the U.S. Environmental Protection Agency (EPA) Region VI and New Mexico Environment Department (NMED), SNL/NM proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all SWMUs exist within the boundaries of the Kirtland Air Force Base (KAFB). Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/NM ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land-use scenarios for the SNL/NM SWMUs. At this time, all SNL/NM SWMUs have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based upon a residential land-use scenario. All three land-use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent Hazard index (HI), risk and dose values. The EPA (EPA 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water
- Ingestion of contaminated soil
- Ingestion of contaminated fish and shell fish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water
- Dermal contact with chemicals in soil
- Inhalation of airborne compounds (vapor phase or particulate)

- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based upon the location of the SNL/NM SWMUs and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land-use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM SWMUs, there does not currently occur any consumption of fish, shell fish, fruits, vegetables, meat, eggs, or dairy products that originate on site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land-use scenarios, SNL/NM ER has, therefore, excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM SWMU:

- Ingestion of contaminated fish and shell fish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

For the residential land-use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based upon this evaluation, for future risk assessments, the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land use scenarios. However, the potential for dermal exposure to inorganics is not considered significant and will not be included. In general, the dermal exposure pathway is generally considered to not be significant relative to water ingestion and soil ingestion pathways but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

Equations and Default Parameter Values for Identified Exposure Routes

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land use scenarios. The general equations for calculating potential intakes via these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a, 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations

Table 1
Exposure Pathways Considered for Various Land Use Scenarios

Industrial	Recreational	Residential
Ingestion of contaminated drinking water	Ingestion of contaminated drinking water	Ingestion of contaminated drinking water
Ingestion of contaminated soil	Ingestion of contaminated soil	Ingestion of contaminated soil
Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)
Dermal contact	Dermal contact	Dermal contact
External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces	Ingestion of fruits and vegetables
		External exposure to penetrating radiation from ground surfaces

used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in RME risk assessment calculations for industrial, recreational, and residential scenarios, based upon EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993).

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., hazard quotients/hazard index [HI], excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \quad (1)$$

where

C = contaminant concentration (site specific)
CR = contact rate for the exposure pathway
EFD= exposure frequency and duration
BW = body weight of average exposure individual
AT = time over which exposure is averaged.

The total risk/dose (either cancer risk or HI) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the constituents of concern (COC) present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of 10^{-4} to 10^{-6}. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the HI) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard HI of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989a) and the RESRAD Manual (ANL 1993). Table 2 shows the default parameter values suggested for used by SNL/NM at SWMUs, based upon the selected land use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL/NM is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways based upon the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL/NM proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land-use scenario. There are no current residential land-use designations at SNL/NM ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land-use, SNL/NM will provide risk parameter values based upon a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on SNL/NM ER sites. The parameter values are based upon EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL/NM will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

References

ANL, see Argonne National Laboratory.

Argonne National Laboratory (ANL), 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD*, Version 5.0, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, IL.

DOE, see U.S. Department of Energy.

EPA, see U.S. Environmental Protection Agency.

Table 2
Default Parameter Values for Various Land Use Scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure frequency (day/yr)	***	***	***
Exposure duration (yr)	30[a,b]	30[a,b]	30[a,b]
Body weight (kg)	70[a,b]	56[a,b]	70 adult[a,b] 15 child
Averaging Time (days) for carcinogenic compounds (= 70 y x 365 day/yr) for noncarcinogenic compounds (= ED x 365 day/yr)	25550[a] 10950	25550[a] 10950	25550[a] 10950
Soil Ingestion Pathway			
Ingestion rate	100 mg/day[c]	6.24 g/yr[d]	114 mg-yr/kg-day[a]
Inhalation Pathway			
Inhalation rate (m^3/yr)	5000[a,b]	146[d]	5475[a,b,d]
Volatilization factor (m^3/kg)	chemical specific	chemical specific	chemical specific
Particulate emission factor (m^3/kg)	1.32E9[a]	1.32E9[a]	1.32E9[a]
Water Ingestion Pathway			
Ingestion rate (L/day)	2[a,b]	2[a,b]	2[a,b]
Food Ingestion Pathway			
Ingestion rate (kg/yr)	NA	NA	138[b,d]
Fraction ingested	NA	NA	0.25[b,d]
Dermal Pathway			
Surface area in water (m^2)	2[b,e]	2[b,e]	2[b,e]
Surface area in soil (m^2)	0.53[b,e]	0.53[b,e]	0.53[b,e]
Permeability coefficient	chemical specific	chemical specific	chemical specific

***The exposure frequencies for the land use scenarios are often integrated into the overall contact rate for specific exposure pathways. When not included, the exposure frequency for the industrial land use scenario is 8 hr/day for 250 day/yr; for the recreational land use, a value of 2 hr/wk for 52 wk/yr is used (EPA 1989b); for a residential land use, all contact rates are given per day for 350 day/yr.

[a] RAGS, Vol 1, Part B (EPA 1991).

[b] Exposure Factors Handbook (EPA 1989b)

[c] EPA Region [illegible] guidance.

[d] For radionuclides, RESRAD (ANL 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

[e] Dermal Exposure Assessment (EPA 1992).

U.S. Department of Energy (DOE), 1996. "Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico," U.S. Department of Energy, Kirtland Area Office.

U.S. Environmental Protection Agency (EPA), 1989a. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual," EPA/540-1089/002, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1989b. *Exposure Factors Handbook*, EPA/600/8-89/043, U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1991. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B)," EPA/540/R-92/003, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1992. "Dermal Exposure Assessment: Principles and Applications," EPA/600/8-91/011B, Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1996. "Soil Screening Guidance: Technical Background Document," EPA/540/1295/128, Office of Solid Waste and Emergency Response, Washington, D.C.

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ADDITIONAL /SUPPORTING DATA

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